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OHIO MOSSES, BRYALES*

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The present paper is a continuation of the study of the mosses of Ohio. The method of procedure and nomenclature used is the same as in the report on the Polytrichales.

BRYALES.

Hermaphroditic or unisexual mosses with archegonia situated at the tip of the main stalks and of ordinary branches. Gametophores usually erect, varying widely in vegetative characters. Scales from broad ovate to setaceous. Sporangium with a definite columnella; peristome double, developed from the ampithecium and derived from the cell walls of a single layer of cells; outer teeth thin, transversely barred, the plates of the outer sides of the segments mostly in two rows separated by a median zig-zag line; the inner teeth membraneous, sometimes lacking; sporangium rarely without a peristome.

SYNOPSIS OF THE ORDER.

I. Teeth of the endostome, when present, alternating with those of the exostome.
  A. Sporangium regular, erect.....ORTHOTRICHIACEÆ
  B. Sporangium elongated or pear-shaped, often with a neck-like hypophysis.
    1. Inner peristome with keeled segments, with inner cilia often present.
      a. Sporangium only slightly or not at all zygomorphic, often pendent; hypophysis short or forming a long neck; inner peristome mostly with well-developed cilia.....BRYACEÆ
      b. Sporangium decidedly zygomorphic, arcuate, long-necked; inner peristome without intermediate cilia.....MEESIACEÆ
    2. Inner peristome with basal membrane bearing cilia only, in twos or fours.....TIMMIACEÆ
  C. Sporangium more or less globose, without a neck-like hypophysis; inner peristome without cilia or with cilia little developed...BARTRAMIACEÆ

II. Teeth of the endostome, when present, opposite those of the exostome, either free or united with those of the outer set.
  A. Endostome processes, when present, free.....FUNARIACEÆ
  B. Endostome processes coherent with the exostome or absent.
    1. Minute cleistocarpous mosses.....EPHEMERACEÆ
    2. Sporangium minute, without a peristome; scales 2-ranked, confluent below, without a mid-rib.....SCHISTOSTEGACEÆ
    3. Sporangium with a very much enlarged hypophysis; scales more than 2-ranked.....SPLACHNACEÆ

* Papers from the Department of Botany, The Ohio State University, No. 174.

KEY TO THE FAMILIES OF BRYALES.

1. Scales 2-ranked, vertically placed forming a continuous margin on the gametophore.....SCHISTOSTEGACEÆ
1. Scales 2 to 8-ranked, not vertically placed..... 2
2. Plants dark except at the tip of the growing gametophores; on rocks and trees.....ORTHOTRICHIACEÆ
2. Plants light green, or if blackish, then growing on the ground..... 3
3. Plants minute, almost microscopic, one-eighth mm. or less; on soil sporangium immersed.....EPHEMERACEÆ
3. Plants larger, 8 mm. or more; on soil, rocks, or trees; sporangium on a seta.. 4
4. Cells on scales papillose..... 5
4. Cells of scales not papillose..... 7
5. Scales crisped when dry, strongly serrate.....TIMMIACEÆ
5. Scales not crisped when dry..... 6
6. Scales obtuse, broadly ovate to oblong-ovate, serrate or entire..MEESIACEÆ
6. Scales acute to acuminate, serrate.....BARTRAMIACEÆ
7. Swollen or expanded hypophysis.....SPLACHNACEÆ
7. Hypophysis tapering..... 8
8. Sporangium nearly actinomorphic, segments of inner peristome alternating with the teeth of the outer peristome.....BRYACEÆ
8. Sporangium strongly zygomorphic, segments of the inner peristome opposite the teeth.....FUNARIACEÆ

ORTHOTRICHIACEÆ.

Gametophytes forming tufts of erect to ascending, dichotomously branched gametophores; scales solid, decurrent, oblong to linear-lanceolate, of mainly one layer of more or less uniform cells; seta erect, often short with the sporangium partly immersed; sporangium actinomorphic, erect, peristome double or single, rarely none, when double the segments alternating with the teeth.

1. Creeping with erect or ascending branches; calyptra cucullate, not plicate, *Drummondia*
1. Mostly erect; calyptra campanulate, plicate..... 2
2. Scales ovate at the base, crisped when dry; sporangium exserted.....*Ulota*
2. Scales not ovate at the base, not crisped when dry; sporangium immersed or emergent.....*Orthotrichum*

1. DRUMMÓNDIA Hook.

Peristome of 16 teeth, distinct to the base, not distinctly twisted nor longitudinally striate; calyptra cucullate; on trees.

Drummondia prorepens Brid. (*Anodontium prorepens* Brid.; *Hypnum clavellatum* Dill.; *Gymnostomum prorepens* Hedw.; *Orthotrichum clavellatum* Hook.; *Drummondia clavellata* Hook.) Creeping, with many erect bulbous branches, radiculose below, dark green almost black, bright at the tips; scales broadly lanceolate, revolute, concave, erect to spreading, entire, costa strong; seta less than one-eighth inch long, reddish-brown, twisted when dry; sporangium short ovoid, almost globose, erect, mouth wide. Fruits in summer. Reported from Lake, Franklin, and Clark Counties.

2. ORTHÓTRICHUM Hedw.

Scales not crisped when dry, bases not oval; stomata immersed in the neck of the sporangium; calyptra less densely hairy than Ulota; otherwise very like it.

1. On rocks; peristome single, teeth erect or erect-spreading when dry..... 2
1. On trees; peristome double, teeth more or less reflexed when dry..... 5
2. Sporangium fully exserted; 16-striate.....*O. anomalum*
2. Sporangium immersed or half-emergent; 8 or 16-striate..... 3
3. Half-emergent; 16-striate.....*O. cupulatum*
3. Sporangium immersed when growing; 8-striate..... 4
4. Sporangium half-emergent when dry; ovate-cylindrical.....*O. strangulatum*
4. Sporangium immersed when dry, ovate-globose.....*O. lescurii*
5. Sporangium strongly contracted below the mouth, deeply 16-striate, striæ reddish-brown.....*O. braunii*
5. Sporangium not strongly constricted below the mouth, less deeply striate, lighter in color.....*O. ohioensis*

Orthotrichum anómalum Hedw. (*O. saxatile* Brid.) Brownish, one-half to one inch tall; scales lanceolate, not crisped when dry, reflexed; sporangium lightly exserted, 16-striate, alternate striæ short and indistinct, hypophysis long and tapering, calyptra with few hairs, peristome teeth cross-barred, not reflexed when dry. On rocks. Autoicous. Early summer. Ottawa County.

Orthotrichum strangulàtum Schw. (*O. porteri* Aust.; *O. cupulatum porteri* Venturi). Densely cespitose, one-third to one-half inch tall, branched; scales dense, ovate to lanceolate, acute, entire or papillose, somewhat revolute, costa strong, ending slightly below the apex; sporangium immersed when growing, may be only slightly so when dry, erect, ovate to cylindric, urn-shaped, 8-striate, reddish-brown, stomata immersed, few; calyptra densely erect-hirsuit, operculum with rounded apiculation, peristome single, teeth often split. On rocks. Summer. No specimens in the herbarium but Jennings reports it as being found in Ohio.

Orthotrichum cupulàtum Hoffm. (*O. strangulatum* Beauv.) Small dense tufts, about one-half inch deep; scales lanceolate, entire, revolute, costa ending below the point; seta short, sporangium half immersed, wide-ovate, 16-striate, with alternate striæ shorter than the others, constricted below the reddish-brown mouth, hypophysis short, calyptra sparingly hairy, covering the whole sporangium. Autoicous. Summer. Clark and Franklin.

Orthotrichum lescùrii Aust. (*O. cupulatum minus* Sull.) Rather densely cespitose, about three-eighth inch tall, branched; scales dense, lanceolate to ovate, acute, entire, revolute, costa ending slightly below the apex; sporangium practically immersed, urn-shaped, ovate-globose, 8-striate, sometimes constricted below the mouth, operculum mamillate. On granite rocks. Spring. No specimen in the herbarium but it is probably found in Ohio.

Orthotrichum braùnii Sch. (*O. strangulatum* Sull.) Cespitose, creeping with erect-spreading branches, less than one-fourth inch tall, dark green with lighter tips; scales entire, acute, revolute, clasping, not crisped when dry, costate; sporangium partly immersed, sharply 8-striate, reddish-brown, deeper color on the ribs, constricted below the mouth when dry, peristome double, teeth recurved, hypophysis short. Morgan Co.

Orthotrichum ohioênsis Sull. (*O. canadense* Sull.) Similar to *O. braunii* except in the nature of the sporangium which is lighter in color, not so deeply constricted below the mouth, nor so deeply 8-striate, neither are the peristome teeth reflexed; the plants are lighter green and taller with ovate-oblong scales; calyptra hairy. Autoicous with the antheridial clusters axillary. Specimen from Franklin County, reported from Lake and Lawrence.

Orthotrichum ohioensis citrìnum (Aust.) Lesq. and Jas. (*O. citrinum* Aust.) Scales lighter green, sporangium light yellow, thin, not constricted. Reported from Lake County.

3. ULÒTA Mohr.

Scales dark green to blackish, lighter at tips of the gametophores, spreading to squarose, concave, usually crisped when dry, costa percurrent or nearly so, strong. Sporangium erect, actinomorphic, striate when dry; stomata superficial on the hypophysis; calyptra mitrate, plicate, usually pubescent with erect hairs; peristome usually double, teeth with a median line on the longitudinal face.

1. On rocks; scales not crisped when dry ..... *U. americana*
1. On trees; scales crisped when dry 2
2. Sporangium smooth, with striæ near the mouth; mouth distinctly narrowed, *U. ludwigii*
2. Sporangium distinctly striate; mouth wide 3
3. Sporangium constricted below the mouth, hypophysis long and tapering, *U. crispa*
3. Sporangium not constricted below the mouth, hypophysis abrupt, *U. crispa minus*

Ulota americàna (Beauv.) Limp. (*Ulota hutchinsiæ* Schimp.; *Orthotrichum hutchinsoniæ* Sm.; *Weissia americana* (Pallis) Lindb.) "American Ulota." Loosely cespitose; scales lanceolate, not bordered, revolute, carinate, strongly nerved, closely appressed, not crisped when dry; seta about one-fourth inch long; sporangium yellowish, cylindric, hypophysis tapering, irregularly 8-striate, with more or less distinct intermediate ridges when dry. Autoicous. Spring. Lake County.

Ulota ludwigii (Brid.) Brid. (*Orthotrichum ludwigii* Brid.; *Weissia coarctata* Lindb.) "Puckered Ulota." Loosely cespitose, creeping with erect branches, one-fourth to three-eighth inches tall, densely tomentose below; scales narrowly lanceolate, long, acute to acuminate, somewhat twisted when dry, dense, entire, revolute, concave at the base, erect-spreading, costa sub-percurrent; seta short, yellowish, twisted when dry; sporangium erect, short-pyriform, striæ short below the mouth, hypophysis long and tapering, perisome usually single. Autoicous. On trees in woods. Summer. No specimen.

Ulota crîspa (L.) Brid. (*U. ulophylla* Broth.; *Orthotrichum crispum* Hedw.; *Bryum crispum* Gmel.; *Weissia ulophylla* Ehrh.) "Crisped Ulota." Densely cespitose, about one-half inch tall, gametophores erect and sparingly branched; scales dense, narrowly lanceolate, curled when dry, erect when moist, entire, acuminate, costa percurrent; seta short, sporangium scarcely emergent, erect, 8-striate, slightly constricted below the mouth, teeth reflexed when dry, hypophysis tapering. Autoicous. On trees. Summer. Not reported from Ohio but Jennings reports it as abundant in western Pennsylvania.

Ulota crispa mìnus Sche. (*U. crispa crispula* Hamm.; *U. crispula* Bruch.; *Weissia ulophylla crispula* (Bruch.) Hamm.) Similar to *U. crispa* in appearance, but with both the gametophores and the scales shortened; seta one-fourth to three-eighth inches long, sporangium erect, sub-globose, not constricted below the mouth, striæ indistinct, hypophysis shorter than in *U. crispa*. Late spring and early summer. No specimen but is reported from Lake County.

BRYACEÆ.

Gametophytes small; upper scales usually larger than the lower ones, not winged nor clasping, often bordered by long narrow cells, costa excurrent, upper scale surface smooth; seta long, sporangium more or less zygomorphic, bent, drooping, or pendulous; pear-shaped, ovoid to cylindrical; calyptra smooth, early deciduous; peristome double, outer teeth 16, segments of the inner peristome alternating with the teeth, segments and teeth about equal in length, inner with a distinct carinate membrane, teeth with a median longitudinal line on the outer face; sporangium smooth when dry; protonema not persistent.

1. Rhizome-like stalk, with erect branches with a conspicuous comal tuft of larger scales ..... *Rhodobryum*
1. Not rhizome-like, but may be inclined or arched, radiculose below; not conspicuously tufted 2
2. Fertile gametophores with more or less tufted scales, sterile shoots longer, arched, often producing rhizoids ..... *Mnium*
2. Gametophores all similar, erect-ascending, radiculose below 3
3. Scales ovate to ovate-lanceolate 5
3. Scales linear-lanceolate to linear 4
4. Scales linear from a broader base, setaceous ..... *Leptobryum*
4. Scales linear-lanceolate ..... *Webera*
5. Scales not bordered; stomata immersed ..... *Mniobryum*
5. Scales bordered; stomata superficial ..... *Bryum*

1. LEPTOBRYUM (Schimp.) Wils.

Cells of scales narrow, linear-rhomboidal; cilia not distinctly appendiculate, scales not bordered, not papillose; sporangium pendulous, pyriform, smooth or only slightly and irregularly wrinkled; costa long-excurrent. Annual.

Leptobryum pyrifórme (L.) Wils. (*Webera pyriformis* Hedw.; *Byrum pyriformis* Hedw.; *Mnium pyriforme* L.) "Long-necked Bryum." Densely cespitose, soft, one-half to one inch tall, yellowish-green, brown and matted below; scales elongated, linear-setaceous, erect-spreading, in dense terminal tufts, margins denticulate above, costa excurrent; seta very slender, one-half to one inch long, light-brown; sporangium pendulous, pyriform, reddish-brown, shiny, hypophysis narrow, tapering, darker than the oval-globose sporangium, operculum hemispherical. Synoicous. Wet shaded rocks and soil. June and July. Reported from Lake and Clark, and is common in greenhouses in Franklin County.

2. WEBERA Hedw. (*Pohlia* Hedw.)

Scales linear-lanceolate above, broadly ovate to obovate below, green to yellowish-green, often glossy, scale-cells linear to rhomboidal,

more than twice as long as broad, costa ending some distance below the apex, margin entire or more or less toothed near the apex only; costa narrow, scales inserted in 2 or 3 rows.

1. Stalks and costa reddish, densely cespitose..... 2
1. Stalks not reddish, costa reddish near the base..... *W. lescuriana*
2. Moist soil in rocky places and clefts of rocks; upper scales long shining, red at the base..... *W. cruda*
2. Wet peaty soil and decaying wood; scales shorter, red only on the costa, *W. nutans*

Webera crùda (L.) Schw. (*Pohlia cruda* Lindb.; *Bryum crudum* Schreb.; *Mnium crudum* L.) Densely cespitose, one to three inch tall stalks reddish, simple; scales erect-spreading, slightly serrate near the apex, glaucous green and shining; sporangium horizontal, cylindrical or only slightly constricted below the mouth, hypophysis indistinct, short, light brown, teeth yellow, seta long. In moist soil and rocky places or in clefts in the rocks. Usually autoicous. Summer. Reported from Lake County by Jennings.

Webera nùtans (Schreb.) Hedw. (*Pohlia nutans* Lindb.; *Bryum nutans* Schreb.) Densely cespitose, branching, one-half to 2 inches tall, green above, dense brown tomentum below; lower scales ovate, upper ones linear-lanceolate in dense terminal tufts, denticulate near the apex, stalks and costa near the base reddish; seta glossy, reddish-brown, one-half to 2 inches long; sporangium horizontal to sub-pendulous, ovoid, light brown, mouth wide, constricted below the mouth, operculum mamillate, convex, hypophysis long tapering. Autoicous. Early summer. Wet soil and wet decaying wood. Commen.

Webera lescuriàna (Sull.) Jaeg. (*Bryum pulchellum* Sull.; *Bryum lescuriana* Sull.) Loosely cespitose, pale, stems not red, simple, ascending; scales small and remote below, larger and more dense above, lanceolate, acuminate, serrulate, recurved, not decurrent, reddish; seta erect, one-third to one-half inch long, yellowish-brown, lustrous; sporangium horizontal to pendulous, yellowish-brown, pyriform, hypophysis short, darker, mouth wide, operculum conic-apiculate to mamillate, peristome teeth yellowish pellucid. On wet soil. Unisexual. May. Fairfield and Lake.

3. MNIOBRYUM (Schimp.) Limp.

Small plants with the upper scales linear-lamceaolate, glaucous-green, cells of the scales more or less rhombic-hexagonal, more than twice as long as broad, never linear except in the margin; cilia not distinctly appendiculate; distinctly serrulate.

Mniobryum wahlenbêrgii (Web. & Mohr.) Jen. (*M. albicans* Limp.; *Bryum wahlenbergii* Schw; *Hypnum wahlenbergii* Web. & Mohr.; *Webera albicans* Schimp.) Loosely cespitose, large up to three inch tall, stalks slender, flexuous, reddish; scales distant, linear-lanceolate, slender and long-pointed; seta erect, slender, flexuous, sharply hooked at the summit; sporangium pendent, reddish-brown, pyriform; wide mouth, no annulus, hypophysis short and wide, stomata immersed. Unisexual. Spring and summer, fruiting rarely. Wet soil of banks and ditches. Athens, Hocking, Butler, Lawrence, Clark, Champaign.

4. BRYUM (Dill.) Schimp.

Smaller mosses, usually densely tufted, non-stoloniferous, densely woven radicles, branching; scales often bordered, costa usually excurrent; sporophytes single, seta long, sporangium usually pendulous, peristome of 16 long lanceolate teeth and 16 segments alternating with the teeth, inner peristome with a basal membrane cilia appendiculate.

1. Branches julaceous, silvery.....*B. argenteum*
1. Branches not julaceous; reddish or green, not silvery..... 2
2. Inner peristome imperfect, membrane often united with the teeth..... 3
2. Inner peristome perfect..... 5
3. Teeth marked longitudinally.....*B. cernuum*
3. Teeth not marked longitudinally..... 4
4. Sporangium actinomorphic or only slightly curved; mouth oblique, small; on wet soil.....*B. ulginosum*
4. Sporangium incurved, zygomorphic; mouth not oblique; dry heaths and walls.....*B. inclinatum*
5. Costa vanishing below the apex.....*B. capillare*
5. Costa percurrent to long-excurrent..... 6
6. Scales long-decurrent; costa short-excurrent..... 7
6. Scales short-decurrent or non-decurrent; costa long-excurrent..... 8
7. Gametophores unisexual.....*B. pseudotriquetrum*
7. Gametophores synoicous.....*B. bimum*
8. Scales short-decurrent.....*B. affine*
8. Scales non-decurrent..... 9
9. Scales distinctly bordered, borders yellowish.....*B. pallescens*
9. Cells at edge of scale narrowed but scarcely forming a border.....10
10. Gametophytes unisexual; operculum deciduous.....*B. caespiticum*
10. Gametophytes synoicous; operculum more persistent.....*B. intermedium*

Brynum cernùum Hornsch. (*B. pendulum* Schimp.; *Cynontodium cernuum* Hedw.) Stalks red, erect; scales ovate-lanceolate, tufted, acuminate, reddish at the base, twisted when dry, costa conspicuous, red near the base, excurrent; seta light brown, copperish, one to one and one-fourth inch long, sporangium pendulous, cylindrical, mouth wide, teeth long acuminate, yellowish below, clear near the tips, inner peristome adherent, segments often split, cilia rudimentary. Synoicous. Spring and early summer. Clark County. Lesquereux lists it from "Southern Ohio."

Bryum inclinàtum (Sw.) Bland. (*Pohlia inclinata* Sw.) Deep green, tufted; scales clasping, acuminate, ovate-lanceolate, denticulate near the apex, red at the base, revolute, long hyaline, with yellowish borders; seta one to one and one-half inch long, sporangium pyriform or slightly curved, narrow at the mouth, brown, cilia none or rudimentary, hypophysis tapering. Summer. On walls and slaty rocks. Summit County.

Bryum uliginòsum Br. and Sch. (*B. cernum* Lindb.; *Cladodium uliginosum* Brid.) Gametophyte similar to *B. inclinatum;* seta one and one-half to two inches long, reddish-brown, lustrous; sporangium horizontal to sub-pendulous, large, often one-quarter inch long, incurved, teeth pale yellow, cilia absent or rudimentary, hypophysis tapering. Autoicous. Late summer. No specimen.

Bryum bimum (Schreb.) Brid. (*Mnium bimum* Brid.) Loosely cespitose, lax, matted together, stalks red, branches sparse; scales long,

slender, lanceolate, decurrent, appressed, revolute, pale, serrulate, in outer portion, slightly twisted when dry, distinctly bordered, costa short-excurrent, purplish-red; seta one to two and one-half inches long, slender, castaneous; sporoangium pendulous, reddish-brown, slightly or not at all constricted below the mouth, frequently upcurved, annulus large, teeth slightly sub-hyaline, segments shorter than the teeth, cilia appendiculate, hypophysis tapering. Syniocous. On wet soil and decaying wood. Summer. Stark, Clark, Lorain, Summit, Hancock, Champaign.

Bryum pseudotriquêtrum (Hedw.) Schw. (*B. ventricosum* Dick.; *Mnium pseudotriquetrum* Hedw.) Similar to *B. bimum* but is unisexual, and generally larger and stouter. Tip of antheridial branch large and discoid. Spring and early summer. Vinton, Clark, Fairfield, Champaign.

Bryum affine (Brid.) Lindb. (*B. cuspidatum* Schimp.; *Webera affinis* Bruch.) Gametophores one-quarter to two inches or more in height; scales densely tufted, slightly decurrent, acuminate, more or less serrulate near the apex, almost entire, revolute, slightly twisted when dry, ovate-lanceolate, reddish near the base, costa excurrent, reddish; seta one to one and one-half inches long, lustrous, castaneous; sporangium horizontal to pendulous, oblong-pyriform, constricted below the mouth when dry, hypophysis tapering, yellowish-brown, operculum convex, mamillate, peristome yellowish-pellucid below, sub-hyaline above, segments shorter than the teeth, cilia appendiculate. Synoicous. Summer. Damp walls and rocks. Not reported from Ohio, but is found in western Pennsylvania near our border.

Bryum intemèdium (Ludw.) Brid. (*Mnium intermedium* Ludw.; *Webera intermedia* Schw.) Dark, bronze green, one-half to one inch tall, stalks reddish, scales tufted, long-acuminate, revolute, almost entire, concave, recurved, slightly decurrent, costa excurrent in a long awn; seta three-quarters to one inch long, copper colored and glistening; sporangium horizontal to almost pendulous, elliptic-pyriform, often in-curved, brown, redder near the mouth, teeth lighter, incurved when dry, hypophysis long tapering and often curved. Synoicous. July and August. Cliffs, walls and wet sand. Clark County.

Bryum pallêscens (Schl.) Schw. (*B. turbinatum* Drum.) Yellowish-green, one-half to two inches deep; scales tufted, sparse below, ovate to ovate-lanceolate, acuminate, erect-spreading, reddish at the base, recurved slightly, twisted when dry, costa excurrent in a long point, toothed, reddish; seta about one inch long, erect, flexuous, lustrous, castaneous, sporangium inclined to sub-pendulous, oblong-pyriform, hypophysis tapering, cilia appendicualte, in threes, yellowish. Autoicous with antheridia on a separate branch. May or June. Rocks and crevices in walls. No specimen, but it is reported from Lake County.

Bryum caespitîcium (L.) Hedw. Gametophores one-half to one inch tall, very slender, light bright green; scales ovate to lanceolate, acuminate, entire, revolute, concave, dense near tip of the gametophore, small and distant below, costa long-excurrent, reddish; seta copper-colored, two-thirds to one-half inch long, flexuous; sporangium horizontal to pendulous, slightly or not at all constricted below the

mouth, cilia appendiculate, segments as long as the teeth, hypophysis tapering. Dioicous. Early summer. Delaware, Fairfield, Clark, Hardin.

Bryum argênteum (L.) Hedw. "Silvery Bryum." Gametophores small and compact, one-quarter to one inch or less; scales broad ending in a bristle, clasping, concave, compressed, light green, silvery when dry, entire, very pellucid, costa ending below the apex; seta one-third to one-half inch long, sharply curved at the top, sporangium pendulous, reddish-brown, slightly constricted below the mouth, cilia as long as the segments, operculum yellowish. Autumn. On dry earth, crevices in walks, etc. Lake, Franklin, Clark.

Bryum capillàre (L.) Hedw. (*Mnium capillare* L.) Gametophores small, one-half inch or more in height; scales dense near the top of the gametophore; light green, lanceolate, revolute, entire, costa brown, excurrent; seta one-half to three-quarters inches long, slender, brown; sporangium horizontal to sub-pendulous, brown, slightly constricted below the mouth, peristome conspicuous, hypophysis long and tapering. Usually unisexual. Summer; fruit rarely found. Loam and leaf mold. Greene County.

5. RHODOBRYUM (Schimp.) Hampe.

Large stoloniferous mosses with clustered sporophytes.

Rhodobryum ontariense (Kind.) Paris. (*Bryum roseum* L. & J.; *Bryum ontariense* Kind.; *Bryum proliferum* (L.) Shibth.; *Mnium roseum* Weis.) "Giant Byrum." Large, yellowish-green, with sudden conspicuous terminal tufts of scales, long and creeping, branches one to two inches tall; scales large, almost one-half inch long, acute, sharply serrate, wavy when dry, costa percurrent; seta one and one-half to two inches long, brown; sporangium paler, slightly curved, horizontal, teeth bordered, hypophysis long and tapering. Unisexual. On rotting wood and humus. Specimens from Champaign, Fairfield and Clark and reported from Franklin by Professor Schaffner.

6. MNÌUM (L.) Hedw. (*Astrophyllum* Neck.)

Large plants, upper scales ovate, cells of the scales rhomboidal-hexagonal, nearly as broad as long, never linear; sporangium cylindric-oblong to ovoid, pendulous; cilia not appendiculate.

1. Scales not bordered.....*M. stellare*
1. Scales bordered..... 2
2. Scales entire or nearly so.....*M. punctatum*
2. Scales distinctly serrate..... 3
3. Scales serrate with a single row of teeth..... 4
3. Scales serrate with a double row of teeth..... 7
4. Scales serrate to the base or nearly so; sporophytes clustered..... 5
4. Scales serrate in outer two-thirds or one-half only..... 6
5. Scales usually acute; lid conic; unisexual.....*M. affine*
5. Scales usually obtuse; lid rostrate; synoicous.....*M. rostratum*
6. Scales not much crisped when dry; sporophytes clustered.....*M. drummondii*
6. Scales much crisped when dry; sporophytes single.....*M. cuspidatum*
7. Scales lanceolate; costa not reaching the apex; dorsally toothed..*M. hornum*
7. Scales lance-ovate; costa percurrent in the upper scales; not dorsally toothed..... 8
8. Peristome red; cells of the scales collenchymatous.....*M. spinulosum*
8. Peristome yellow; cells of the scales not collenchymatous.....*M. serratum*

Mnium hòrnum (L.) Hedw. (*Astrophyllum hornum* Lindb.) "Long-scaled Mnium." Cespitose, dark to bright green, one to two inches tall, unbranched, scales long-acuminate, curled when dry, costa distinct, ending below the apex, scales on the sterile shoots crowded, antheridial branch tip discoid; seta one-half to three-quarters inches long, reddish-brown, slender; sporangium yellow with a red mouth, sub-pendulous, ovate-elliptical, calyptra often clinging to the seta. Unisexual. On cliffs near streams or on sandy banks. Franklin County.

Mnium serràtum (Schrad.) Schw. (*M. marginatum* Beauv.; *Astrophyllum marginatum* Lindb.; *Bryum serratum* Schrad.) Loosely cespitose, one-half to one inch tall, dark, stalks reddish, densely tomentous below; scales distant, ovate to obvoate, acute, costa reddish, percurrent in the upper scales, shorter below, serrate margins reddish, strongly decurrent; seta one-half to three-quarters inches long, pale, sporangium horizontal, ovoid, light yellow, hypophysis tapering, operculum rostrate. Synoicous. Early spring. Moist shaded banks or in crevices of rocks. Reported from Ohio by Lesquereux, but no specimens are in the herbarium.

Mnium spinulòsum Br. & Sch. "Red-mouthed Mnium." Less than one inch tall; scales obovate to spatulate, acute, decurrent, reddish bordered, costa usually percurrent, sporophytes single or clustered; erect; sporangium inclined to horizontal, ovate-oblong, light yellowish, annulus bright red, peristome red, operculum decidedly rastrate. On ground in evergreen woods. Reported from Lake County.

Mnium rostràtum (Schrad.) Schw. (*Astrophyllum rostratum* Lindb.; *Bryum rostratum* Schw.) Large, loosely cespitose, stoloniferous, branches erect, short; scales oblong to obovate, obtuse, costa shortly excurrent; sporophytes 1–3, sporangium horizontal to sub-pendulous, yellowish, peristome yellow, inner peristome orange, operculum rostrate. Synoicous. Spring. Earth or rocks in moist shady places, wet by spray. Specimen from Fairfield. Reported from Champaign.

Mnium cuspidàtum (L.) Hedw. (*M. sylvaticum* Lindb.; *Astrophyllum sylvaticum* Lindb.) "Woodsy Mnium." Cespitose, prostrate to suberect, about one inch tall, light green, brown radiculous below; scales distant, oblong-ovate or somewhat ovate, acute, decurrent, keeled, wavy when dry, serrate in the upper half, teeth usually of one cell, costa strong, vanishing below the apex; seta about one inch long, solitary, light brown, glistening; sporangium horizontal to sub-pendulous, light brown, peristome light, cilia as long as the teeth, hypophysis very short, deeper brown, calyptra pointed, splitting on the side. Synoicous. May. Cosmopolitan on rotten wood, stones and soil. Common.

Mnium drummôndii Br. & Sch. Gametophytes one to one and one-half inches tall, loosely cespitose, with dense brown tomentum below; scales distant, large, one-eighth inches long, broadly ovate, mucronate, costa excurrent; seta one and one-half to two inches long, slender, flexuous, copper-colored, sharply curved; sporangium pendulous, light brown, ovoid, reddish at the mouth, segments of the inner peris-

tome as long as the teeth, hypophysis short. May–June. No specimen in the herbarium, but it is reported from Lake County by Claassen.

Mnium affine (Bland. Schw.) (*M. cuspidatum* Neck.; *Astrophyllum cuspidatum* Lindb.) Gametophytes large, one to three inches tall, pale green, darker when older, brown radiculous below; scales widely distant, ovate, acute, narrow at the base, decurrent, serrate to the base, border pellucid or often yellowish or reddish, teeth single; costa distinct, excurrent; tip of antheridial branch discoid, large; sporophytes usually clustered, seta reddish; sporangium pale yellow, pendent, ovoid-elliptical, cilia as long or longer than the teeth, hypophysis short. Unisexual. May. Rocks and wet soil. No specimen.

Mnium affine ciliàre (Gren.) Muell. (*Astrophyllum ciliare* Lindb.) *Bryum ciliare* Grev.) "Toothed Mnium." Similar to *M. affine* with the exception that the sporophytes are single and never clustered, and the teeth on the scales are longer than in *M. affine*. Franklin, Champaign, Hardin.

Mnium affine rùgicum Br. & Sch. (*Astrophyllum rugicum* Lindb.) Smaller, blackish with lighter green tips; scales oblong to orbicular, teeth almost obsolete, almost entire, very short; apex rounded; sporophytes single. Cool shaded ravines and swamps. Spring. Not reported but may be found.

Mnium stellàre (Reich.) Hedw. (*Astrophyllum stellare* Lindb.) Densely cespitose, one-third to two inches tall, deep or bluish-green, soft, erect, branching at the base; scales slightly decurrent, apex rounded to obtuse-apiculate, dense, oblong-elliptic, slightly crisped when dry, non-bordered, teeth obtuse, rather distant in the outer half, costa ending well below the apex; tip of antheridial branch discoid; sporophyte solitary, sporangium inclined to horizontal, oblong, operculum conic-convex, peristome yellowish. Unisexual. Summer. Rarely found in fruit. Bases of trees in swampy woods. There is no specimen in the herbarium, although Beardslee reports this species as common and Miss Biddlecomb reports it from Clark County.

Mnium punctàtum (L.) Hedw. (*Astrophyllum punctatum* (L.) Lindb.) "Early Mnium." Large, one to three inches tall, loosely cespitose, dark green, radiculose almost to the top; scales broad ovate, blunt, narrow at the base, scarcely decurrent, margin thick, costa strong, large up to one-quarter inch long; seta to one inch long, brown, sporangium sub-pendulous, light, becoming darker, operculum acutely rostrate, peristome yellowish, papillose. Unisexual. Early spring. This species is reported common by Beardslee, but there is no specimen in the herbarium.

MEESIACEÆ.

Gametophytes small to medium size; scales 3–8-ranked, with laminæ of one layer of more or less uniform cells, not clasping, lanceolate to lance-ovate, recurved to spreading, squarose, obtuse or rounded, costa strong; seta usually very long and slender; sporangium arcuate with long tapering hypophysis, not constricted below the mouth; outer peristome of 16 teeth with a median line on the outer face, inner peris-

tome of 16 segments alternate with the teeth, keeled, cilia rudimentary, with a carinate basal membrane; calyptra cucullate. In bogs frequently with sphagnum.

1. Peristomes of equal length; surface cells of the scales papillose; sporangium striate when dry.....*Aulacomnium*
1. Inner peristome longer than the outer; surface cells of the scales not papillose; sporangium smooth or irregularly sulcate when dry.....*Meesia*

1. AULACÓMNIUM Schw.

Scales strongly costate, cells collenchymatous; sporangium ovoid-cylindrical, somewhat zygomorphic, ribbed when dry, outer and inner peristome of equal length.

1. Scales ovate, strongly serrate; autoicous.....*A. heterostichum*
1. Scales lanceolate, serrate near the apex only; unisexual.....*A. palustre*

Aulacumnium heterόstichum (Hedw.) Br. & Sch. (*Sphaerocephalus heterostichus* (Brid.) Britt.; *Arrhenopterum heterostichum* Hedw.; *Orthopyxis heterosticha* Beauv.) Loosely cespitose, much branched, yellowish-green, one to one and one-half inches tall, more or less prostrate, radiculous below; scales ovate, lower ones obovate, rounded at the tip, costa yellowish-brown extending to just below the apex; seta reddish-brown, one-tenth to one-third inches long, sporangium reddish, curved, inclined, oblong-cylindric, 8-striate, hypophysis tapering, peristome light yellow, cilia slightly shorter than the teeth, operculum with a short blunt point. May and June. on rocks and sandy soil in the shade. Common throughout the state.

Aulacomnium palûstre (L.) Schw. (*Mnium palustre* L.; *Sphœrocephalus palustris* (L.) Lindb.) "Ribbed Bog-Moss." Cespitose, branching, one to five inches tall yellowish-green with brown tomentum below, scales linear-lanceolate, to wider, acuminate, costa to just below the apex, serrate near the tip, crispate when dry, cells papillose; seta three-quarters to two inches long, yellowish-brown, twisted; sporangium arcuate, constricted below the mouth, reddish-brown, 8-striate, hypophysis long-tapering, a distinct line separating it from the body of the sporangium, peristome yellowish, operculum conic with a short blunt tip. Antheridial tip discoid. Reported from Lake County by W. C. Werner.

Aulacomnium palustre polycephalus Br. & Sch., which is reported from Champaign County by Werner, is described by Dixon as "a gemmiferous form" which produces pseudopodia from the axils of the scales and he thinks it a state rather than a true variety.

2. MÈESIA Hedw.

Sporangium smooth, not ribbed when dry, segments two or three times as long as the teeth; costa thick.

1. Scale margins revolute, apex rounded.....*M. trichoides*
1. Scale margins plane, apex acute..... 2
2. Scales entire, 5 to 8-ranked.....*M. longiseta*
2. Scales serrate, 3-ranked.....*M. triquetra*

Meesia trichoìdes Spruce. (*Bryum trichoides* L.; *Meesia uliginosa* Hedw.) Dense pale green tufts; scales long and narrow, in 8 rows. Synoicous. No specimen.

Meesia triquêtra (L.) Angstr. (*M. tristicha* Br. & Sch.) Loosely cespitose, dark green, radiculose below, sparingly branched; scales lanceolate, acute, decurrent and half-clasping, distant, keeled, squarose; sporangium pyriform, curved from a long erect collum, more or less twisted and wrinkled when dry, segments of the inner peristome about three times as long as the teeth, yellowish, operculum convex. In peat bogs. Reported from Southern Ohio, in H. C. Beardslee's catalog.

Meesia longiséta Hedw. Scales entire, decurrent, lanceolate, gradually spreading from an erect base, not squarose, crisped when dry. Synoicous. "Cranberry swamps in northern Ohio, not rare" according to Lesquereux and James.

BARTRAMIACEÆ.

Large deep tufts or cushions of branched gametophores, protonema persistent; scales papillose, not winged or clasping, laminæ of mainly one layer of more or less uniform cells; sporangium sub-globose, ribbed when dry, drooping, inner peristome shorter than the outer with a distinct carinate basal membrane, outer peristome of 16 teeth with a median line on the outer face.

1. Cilia rudimentary or lacking; scales linear-lanceolate.....*Bartramia*
1. Cilia well-developed, except in *P. muhlenbergii;* scales ovate-lanceolate, *Philonotis*

1. BARTRÁMIA Hedw.

Scales little or not at all decurrent, cells papillose; sporangium striate, somewhat globose.

Bartramia pomifórmis (L.) Hedw. (*Bryum pomiforme* L.) "Apple Moss." Cespitose, matted, soft, one-fourth to two inches tall, yellowish-green, dense, brown tomentum below; scales elongated, somewhat decurrent, spreading, concave at the base, margins revolute in the lower part, serrate near the tip, crowded, costa excurrent, distinct; seta reddish-brown, one-quarter to one-half inches long, sporangium light-brown, globose, 16-striate, zygomorphic, peristome reddish, segments shorter than the teeth, operculum short-umbonate. Cosmopolitan mosses found on rocks and moist soil in the shade. May and June. Common.

2. PHILONÒTIS Brid.

Water-loving mosses with well-developed cilia; usually unisexual.

1. Scales not dimorphic, cilia rudimentary.....*P. muhlenbergii*
1. Scales dimorphic, cilia well-developed..... 2
2. Perigonial bracts obtuse, triangular, ovate, costa not reaching the apex, *P. fontana*
2. Perigonial bracts long-acuminate with excurrent costa.....*P. calcarea*

Philonotis muhlenbérgii (Schw.) Brid. (*P. marchia* Sull.; *Bartramia muhlenbergii* Schw.) Cespitose, yellowish-green, brown below, gametophores slender, stalks reddish, one-half to one and one-half inches tall, branches whorled; scales lanceolate to ovate, long-acuminate, distant, decurrent, falcate-secund, ascending or appressed, somewhat crisped when dry, serrate in the outer portion, costa percurrent; seta copper-

colored, glistening, slender, flexuous; sporangium globose, zygomorphic, faintly striate, arcuate, cernuus, neck sunken when dry, brown, teeth reddish, operculum almost flat, umbo short. June. Wet rocks. Lake and Clark.

Philonotis calcàrea Schimp. (*Bartramia calcarea* Br. & Sch.) Densely cespitose, soft, bright green, somewhat glaucous above, branches in whorles, slender, erect, three to four inches tall; reddish-brown dense tomentum below; scales broadly ovate on the main stem, acuminate, concave, plicate, serrulate toward the apex, margin revolute, base slightly decurrent, erect-spreading to secund, costa strong, dorsally papillose; branch scales lanceolate, falcate-secund; sporangium similar to *P. fontana*. Summer; rarely in fruit. Calcareous bogs and swamps. Not reported but may be found.

Philonotis fontàna (L.) Brid. (*Mnium fontanum* L.; *Bartramia fontana* Swartz.) Gametophyte tall, one to five inch stalks very slender, red, brown tomentum below; scales small, appressed, usually turned to one side when dry, ovate-lanceolate, acuminate, yellowish-green, costa often excurrent into a short point; seta red. One-half to one and one-half inches long; sporangium brownish, oblong, arcuate, striate, teeth reddish-brown; tips of antheridial branches red and discoid. Dripping rocks and swampy places. Lake, Licking, Fairfield.

TIMMIACEÆ.

Robust mosses, dull yellowish-green with brown tomentum below, scales spreading to recurved, base half-sheathing, non-decurrent, non-bordered, serrate, costa percurrent; sporangium cernuus to almost pendent, peristome double.

1. TÍMMIA Hedw.

Protonema not persistent; upper scale surface papillose; sporangium smooth not ribbed when dry; inner peristome with a distinct basal membrane, cilia as long as the teeth.

Timmia cucullàta Rich. (*T. megapolitana* Hedw.) Large moss resembling Polytrichum; scales narrow, long, coarsely serrate, in six series, spreading to recurved; seta straight at end of stalk; sporangium curved, ovoid to cylindrical, regularly furrowed when dry, hypophysis tapering, peristome double, teeth equidistant, inner peristome of cilia only in groups of fours, zygomorphic, strongly curved when dry, tapering gradually to the seta, calyptra remaining on the seta. May. Moist soil and bases of trees. Clark County.

FUNARIACEÆ.

Protomena sometimes persistent; upper scales concave forming a rosette, costa distinct, rarely excurrent; seta red and twisted, segments of the inner peristome opposite the teeth, keeled, no basal membrane, no cilia; mostly on moist earth or earth-covered rocks.

1. Protonema not persistent; scales without costa..... 2
1. Protonema persistent; scales without costa; calyptra splitting and remaining on the seta..... *Discelium*
2. Sporangium curved or mouth tilted to one side, peristome usually double; seta elongated..... *Funaria*
2. Sporangium actinomorphic, peristome none..... 3
3. Sporangium splitting equatorially, immersed and almost sessile, *Aphanorhegma*
3. Sporangium definitely operculate, with a long seta or immersed, *Physcomitrium*

1. APHANORHÉGMA Sull.

Earth mosses, light green, radiculose at the base, glabrous; cells elongated above the middle of the scales.

Aphanorhegma serràtum (Hook & Wils.) Sull. (*Physcomitrium serratum* Muell.) Gregarious, erect, simple or forked, small; lower scales spreading, oblong-lanceolate, upper ones more erect, larger, spatulate-lanceolate, sparingly serrate above the middle, apex acute to acuminate, costa almost to the tip; seta short and stout; sporangium immersed, brown, annulus near the middle, calyptra mitreform; spores orange. Autumn. Wet clay soil. Reported from Ohio by Lesquereux.

2. PHYSCOMÍTRIUM (Brid.) Fuer.

Earth mosses, light green; cells elongated above the middle of the scales; sporangium exserted on a long seta, or if immersed then with 1–3 rows of denser cells below the line of dehiscence; sporangium operculate, erect, no peristome, calyptra mitrate.

1. Sporangium immersed, mouth wide, calyptra small..... *P. immersum*
1. Sporangium exserted, mouth narrow, calyptra larger..... *P. turbinatum*

Physcumitrum immêrsum Sull. (*Gymnostomum immersum* Sull.) Gregarious, one-eighth to one-quarter inch tall, antheridia in axils of the scales, branches bearing the archegonia coming from below; scales obovate to lanceolate, costa ending below the apex, serrate above the middle; sporangium immersed, globose, brown, erect, operculum apiculate, rostrate. Autumn. Clay banks where they are sometimes submerged. Reported from Lake County and from "river banks of southern Ohio" by Lesquereux and James.

Physcomitrium turbinàtum (Rich.) Muell. (*P. pyriforme* E. G. Britt.; *Phascum strangulatum* Kind.; *Phascum hookeri* Macoun.) "Urn Moss." Gregarious, small, one-half inch or less, erect; scales slightly serrulate, oblong or oblanceolate, curled when dry; seta pale, slender to one-half inch long, sporangium erect, actinomorphic, globose to pyriform, turbinate and constricted below the mouth when empty, operculum flatly convex, rostrate, blunt, short. Autoicous. Late spring or early summer. On bare soil under trees and by roadsides, also on earth in greenhouses. Specimens from Franklin, Trumbull, Clark, Lawrence and Hamilton; reported from Lake.

2. FUNÀRIA (Schreb.) Hedw.

Protonema not persistent, scales not clasping or winged; sporangium operculate, wrinkled when dry; calyptra cucullate; inner peristome

usually distinct, lacking a basal membrane or cilia, outer peristome of 16 teeth with a median longitudinal line on the outer face. Autoicous.

1. Scales short-acuminate, costa mostly percurrent..... *F. hygrometrica*
1. Scales long-acuminate, costa excurrent in some of the scales..... 2
2. Sporangium striate and more or less plicate, annulus large..... *F. flavicans*
2. Sporangium neither striate nor plicate, no annulus..... *F. americana*

Funaria americàna Lindb. (*F. muhlenbergii* Hedw.) Small, gregarious, loosely cespitose; scales erect-spreading, long-acuminate, oblong-ovate, entire, not revolute, costa excurrent; seta twisted when dry, sporangium erect, mouth to one side, curved when dry, smooth, hypophysis long and tapering, rugose when dry. May. On soil. No specimens. Reported from Ohio by both Jennings and Grout.

Funaria flávicans (Rich.) Michx. Atheridial gametophores erect; lower scales small, sparse, and ascending; upper ones tufted and spreading, lanceolate, long-acuminate, entire, costa excurrent; archegonial gametophores shorter, scales ovate, acute; seta reddish-yellow, glistening, one to one and one-half inches long; sporangium arcuate, reddish-brown, striate, hypophysis tapering, operculum almost flat, not apiculate, calyptra long-pointed. May or June. Moist clay soil. Specimens from Lucas and Lawrence.

Funaria hygrométrica (L.) Sibth. (*Mnium hygrometricum* L.) "Cord Moss." Gametophyte one-eighth to one-third inches erect, radiculose; scales wide ovate, acute, concave forming a bulbous tuft, light green, entire or nearly so, costa dark red, percurrent; seta copper-colored to dark red, slender, flexuous, twisted when dry, one to two inches long; sporangium strongly arcuate, mouth to one side; reddish, yellowish, or brown; striate, hypophysis tapering, operculum almost flat, not apiculate, annulus conspicuous, calyptra long-rostrate, peristome teeth united by their tips to a small disk. Autoicous. May or June. Common on soil especially on burnt-over ground. Throughout the state.

Funaria hygrometrica clavéscens Br. & Sch. (*F. clavescens* Schw.) Similar to *F. hygrometrica* only more robust, being one to 2½ times all dimensions. Dixon says that this is a luxuriant form of the preceding species developed under moist conditions. Reported from "Ohio" by Lesquereux.

4. DISCÉLIUM Brid.

Protonema persistent; gametophytes practically stemless, scales ecostate; calyptra splitting down one side and usually remaining attached to the seta; sporangium operculate. Unisexual.

Discelium incarnàta Schw. (*D. nudum* (Dicks.) Brid.; *Bryum nudum* Dicks.; *Weisia incarnata* Schw.) Protonema brown; gregarious, gametophores almost microscopic, bud-like; scales entire, ovate; seta brown, one-half to one inch long, twisted when dry, sporangium zygomorphic, globose, inclined to horizontal. On clay or sandy banks. Lake and Delaware.

EPHEMERACEÆ.

Sporangium non-operculate; minute plants on soil; costa usually present, scales linear to obovate; sporangium immersed, sub-globose, cleistocarpous; protonema usually persistent.

1. Scales lanceolate; green protonema persistent.....*Ephemerum*
1. Scales ovate; protonema not persistent..... 2
2. Scales erect; stalk none; costa percurrent or excurrent.....*Acaulon*
2. Upper scales rosette-like and spreading, stalk long or short, costa ending below the apex.....*Physcomitrella*

1. EPHÉMERUM Hampe.

Green protonema persistent; upper scales elongate lanceolate to linear; sporangium globose and apiculate; fruiting in autumn.

1. Scales ecostate, strongly serrate.....*E. serratum*
1. Scales costate..... 2
2. Costa ending at or below the apex.....*E. cohaerans*
2. Costa excurrent, scales gradually long-acuminate.....*E. crassinervum*

Ephemerum serràtum (Schreb.) Hampe. (*Phascum serratum* Schreb.) Minute, protonema green and abundant; scales lanceolate to linear, erect, margin coarsely serrate; sporangium globose, apiculate, submerged, brown, glistening. Unisexual. Autumn. Bare soil. Cuyahoga County.

Ephemerum cohàerans (Hedw.) Hampe. (*Phascum cohaerans* Hedw.) Minute, densely gregarious; scales erect-spreading, oblong-lanceolate to ovate-lanceolate, slender, long-acuminate, strongly serrate. Reported by Jennings as occurring in Ohio.

Ephemerum crassinérvum (Sch.) Muell. (*Phascum crassinervum* Schw.) Minute, gregarious; scales linear-lanceolate, erect-spreading, long-acuminate, coarsely serrate above; seta short, sporangium immersed, globose, apiculate, half-covered by the calyptra. Unisexual. Late autumn and early spring. On wet and swampy soil in open fields. Reported by Jennings as occurring in central Ohio.

2. ACAÛLON Muell.

Green protonema not persistent; plants fruit mainly in the spring; scales broad-ovate, erose-denticulate at the tip, smooth, margins more or less revolute; sporangium not at all or only slightly apiculate, subglobose, immersed; spores numerous.

1. Uppermost and perichaetial scales carinate, reflexed.....*A. triquetrum*
1. Uppermost and perichaetial scales concave, plane.....*A. rufescens*

Acaulon triquètrum (Spruce.) Muell. (*Sphaerangium triquetrum* Schimp.; *Phascum triquetrum* Spruce.) Gregarious, minute, gametophores bulbous, pale green or yellowish; scales broadly ovate, deeply carinate, reflexed, irregularly denticulate above, costa excurrent, apiculate, recurved; seta arcuate; sporangium globose, smooth. Early spring. Sandy soil. Reported from Ohio by Jennings.

Acaulon rufèscens Jaeg. (*Phascum rufescens* Kindb.) Minute, bulbiforn, yellowish-green; upper scales deeply concave, margins plane, irregularly denticulate at the apex, costa excurrent into a recurved

apiculus; seta and sporangium as in *A. triquetrum*. Moist clay and sandy soil. No specimen. Reported as common in the central states by Lesquereux and James.

3. PHYSCOMITRÉLLA Br. & Sch.

Protonema not persistent, fruiting mainly in the spring; scales spreading, rosette-like, dentate or serrate, not crisped when dry, smooth, margins plane or involute; sporangium globose to ovoid, non-apiculate, calyptra companulate.

Physcomitrella pâtens (Hedw.) Br. & Sch. (*Phascum patens* Hedw.) Gregarious, pale green; scales lance-ovate to oblong or oval, short acuminate, serrate above, costa ending below the apex; seta short; sporangium globose, brownish, immersed or slightly emergent, usually splitting equatorially, obtusely apiculate; antheridia sessile in the upper axils. Paroicous. Autumn. Wet clay and sandy soil on banks or bottoms of streams. Lesquereux and James lists it as "not rare in Ohio."

SCHISTOSTEGACEÆ.

Plants small, about one-fourth inch tall, slender, sterile stalks with scales distichous, their bases confluent; fertile ones with a tuft of scales; scales ecostate; sporangium minute, erect.

1. SCHISTÓSTEGA Mohr.

Gregarious annuals, propagating often by brood bodies on the protonema. Unisexual.

Schistostega pennàta (Hedw.) Hook & Tay. (*S. osmundaceae* Mohr.; *Gymnostomum pennatum* Hedw. *Mnium osmindaceum* Dick.) "Luminous Moss." Protonema persistent and abundant, green and glistening; seta erect, very slender, sporangium globose, operculate, no stomata, peristome none. Spring. Fruits sparingly. Crevices and dark holes in rocks or the ground. Reported from Geauga County.

SPLACHNACEÆ.

Scales not papillose; hypophysis usually wider than the sporangium peristome single; growing on decaying animal matter.

1. SPLACHNUM (L.) Hedw.

Loose tufts, light to yellowish-green; scales obovate to broad-lanceolate; seta long, sporangium cylindrical to ovoid, 16 peristome teeth, usually reflexed when dry.

Splachnum ampullaceum (L.) Hedw. Stalks slender, one-half to one inch tall; scales distant, lanceolate, acuminate, coarsely serrate, red at the base when old, costa percurrent or nearly so; seta red, 1 to 2 inches long; hypophysis much wider than the sporangium, narrowing to the seta below, smooth, wrinkled when dry, purplish; sporangium brownish-yellow. Summer. Reported by Lesquereux and James as being found in the cranberry swamps of Ohio.

SEX-LIMITED CHARACTERS IN HETEROSPOROUS SPOROPHYTES.*

JOHN H. SCHAFFNER

It appears that sex-limited characters and sexual dimorphism have in the past been considered mostly from the animal side of the subject. For this reason it was thought advisable to give a brief account of some of the more common species which show dimorphism in the sporophyte. The gametophytes of homosporous plants also often show decided sexual dimorphism and the gametophytes of the heterosporous plants exhibit the most extreme dimorphism of any organisms, whether plant or animal.

In order to get a correct understanding of sex-limitation it is best to study sex-limited characters in monecious plants first; for in this case the factors involved can be had in the homozygous condition and the sexual state arises directly from a neutral condition in the vegetative tissues. There are also no allosomes to complicate conditions. In monecious plants the two types of flowers may be commingled in the same inflorescence as in *Aesculus glabra* or in different parts of the same inflorescence, or the inflorescences may themselves be monosporangiate and variously distributed or related to each other on the plant. Two characteristic types are the following: 1st. The staminate flowers are developed first, the inflorescence axis passing from the neutral to the male condition and later this male condition is reversed, passing thru a neutral condition over to the female condition when carpellate flowers are developed. This is the androgynous condition, as in *Carex trisperma*, *Ricinus communis*, and *Zizania aquatica*, and the progression of sexual states corresponds to the normal progression in the flower axis itself. 2nd. The carpellate flowers are developed first and the inflorescence axis changes later from the female state thru a neutral condition, to the male state when staminate flowers are produced above. This is the gynandrous condition and is just the opposite of what normally takes place in the flower axis itself of angiosperms. Examples are *Carex capita*, *Sagittaria latifolia*, *Peltandra virginica*, and *Typha latifolia*. Unfortunately these terms, or at least the first one, have been used in exactly the opposite sense in descriptive botany to designate position on the inflorescence axis.

* Papers from the Department of Botany, The Ohio State University, No. 170.

But it would be very confusing to say that an inflorescence or a plant was androgynous in the genetic sense when the carpellate flowers because of the female condition come first. And it is becoming more evident continually that the dead biology of the past must give way to a "living" or dynamic biology. The terms proterandrous and proterogynous are not available since they refer rather to ripening of the pollen and stigma than to the time of the development of the sporophylls on the axis.

It is evident from the sexual conditions in monecious and hermaphroditic plants that sex-limitation is not a matter of dominance and recessiveness but rather of activity and latency thru the influence of the given sexual state. With the change in sexual state in some part of the body the suppressed factors become active whenever the proper differentiation stage is attained.

Sex-limited characters in the lowest types of heterosporous sporophytes appear only in the sporangia or their stalks. In the second stage of evolution, dimorphisms appear in the sporophylls themselves and as a general rule the diversity increases with the higher types. In the third stage sexual dimorphisms appear between the staminate and carpellate flowers outside of the sporophylls themselves, and the same kinds of differences are to be observed between the flowers whether the plants are monecious or diecious. The fourth stage of evolution of dimorphism shows differences in entire inflorescences; and in the fifth step the sex-limited characters show also in the leaves and stems some distance beyond the inflorescences. In the sixth and extreme case, present typically only in diecious plants all parts of the body may show dimorphic characters in relation to sex.

Sex-limited characters, when they appear on unisexual individuals, have in the past played a prominent part in fantastic speculations on evolution by sexual selection. But when it is realized that the same dimorphisms appear in the sexually differentiated parts of hermaphrodites and monecious species and that the most extreme dimorphisms are to be found in plants which have neither eyes nor the nervous equipment with which to make a choice the whole subject of sexual selection can be easily relegated to the domain of fairyland.

Below is given a small list of the various types of sex-limited characters in heterosporous sporophytes to show the general nature of such characters in the higher plants. For sex-limited characters due to allosomes and characters which show a pecul-

iar migration or transmission because their factors are allosome-linked altho not necessarily sex-limited, one must at present go to the animals.

Plants with Bisporangiate Sporophylls or with Bisporangiate Flowers.

1. *Marsilea quadrifolia*—Microsporangia with long, slender stalks; megasporangia with short, robust stalks.
2. *Selaginella kraussiana*—Microsporophyll with a smaller, acuminate blade; megasporophyll with a larger, acute blade.
3. *Aquilegia canadensis*—Carpel covered with hairs, stamen glabrous.

Small differences in character expressions of this nature are almost universal in the sporophylls of seed plants.

Monecious Plants.

1. *Taxodium distichum*—Dimorphic inflorescences; staminate cones numerous in a slender catkin-like panicle, carpellate cones few in a small terminal cluster.
2. *Larix laricina*—Staminate flowers pale yellow, carpellate flowers rose-red; stamens and carpels structurally different.
3. *Pinus sabiniana*—Staminate flowers yellow, carpellate flowers dark purple; stamens without a special outgrowth, carpels with a special ovuliferous scale.
4. *Pinus radiata*—Staminate flowers yellow, carpellate flowers dark purple; stamens without a special outgrowth, carpels with a special ovuliferous scale.
5. *Limnobium spongia*—Staminate flowers long-peduncled; carpellate flowers sessile or with a short peduncle.
6. *Cocos nucifera*—Staminate flowers with apocarpous vestigial carpels, small sepals, and narrow petals; carpellate flowers syncarpous with very large broad sepals and broad petals.
7. *Zizania aquatica*—Lemma of staminate flower without an awn; lemma of carpellate flower with a long awn.
8. *Tripsacum dactyloides*—Carpellate part of inflorescence with modified rachis with the spikelets in deep pockets; staminate spikelets on an ordinary ranchis.
9. *Euchlaena mexicana*—Decided differences between the staminate and carpellate inflorescences and their bracts; carpellate rachis extremely modified into pockets.
10. *Zea mays*—Decided sexual dimorphism between the two inflorescenes and the internodes and their leaves below.
11. *Liquidambar styraciflua*—Carpellate flowers in a simple spherical head; staminate flowers in racemose clusters.
12. *Sarcobatus vermiculatus*—Staminate flowers without a calyx in scaly spikes; carpellate flowers with a compressed calyx, sessile and solitary.
13. *Eurotia lanata*—Staminate flower with a four-parted calyx; carpellate flower with two united bracts covered with long hairs.
14. *Quercus* sp. Staminate flowers without involucres, in long flexible catkins; carpellate flowers solitary or clustered, with a prominent expanded cup and involucre.

15. *Alnus* sp.—Staminate and carpellate catkins and their bracts decidedly different.
16. *Ostra virginica*—Bracts of the staminate and carpellate inflorescences decidedly dimorphic.
17. *Carpinus caroliniana*—Bracts of the staminate and carpellate inflorescences different.
18. *Juglans nigra*—Carpellate flowers solitary or several in a cluster at the end of a short peduncle; staminate flowers in long flexible catkins.
19. *Hicoria* sp.—Inflorescences with dimorphisms similar to Juglans.
20. *Croton capitatus*—Staminate flowers racemose with a 5-parted calyx and 5 petals; carpellate flowers sessile, with 7-12 sepals and no petals.
21. *Littorella uniflora*—Staminate flowers on slender scapes; carpellate flowers sessile.
22. *Cyclanthera dissecta*—Staminate flowers racemose on long peduncles; carpellate flowers solitary on very short peduncles.
23. *Sicyos angulatus*—Staminate flowers corymbose or racemose on a long peduncle; carpellate flowers capitate on a shorter peduncle.
24. *Ambrosia* sp.—Carpellate and staminate heads decidedly dimorphic.

Examples to show that Sex-limited Characters are similar in Monecious and Diecious Species.

1. *Naias flexilis*, monecious—Carpellate flower without a spathe, staminate flower with a double spathe or sheath.
2. *Naias marina*, diecious—Flowers of the same nature as in the monecious species.
3. *Carex lupulina* and most other species, monecious—Carpellate flowers with a sack-like perigynium; staminate flowers without a perigynium.
4. *Carex dioica*, diecious—Carpellate and staminate flowers of the same nature as in the monecious species.

Diecious Plants.

1. *Cycas revoluta*—Staminate and carpellate plants with very extreme sex-limited characters. Carpellate plant flowerless, the carpels in a rosette, staminate plant with determinate cones. Carpels with a compound leaf blade, stamens simple.
2. *Taxus canadensis*—Carpellate flower with one reduced carpel; staminate flower with 5-8 stamens.
3. *Hydrocharis morsus-ranae*—Flowers decidedly dimorphic, the staminate and carpellate flowers on two different evolutionary levels. Staminate flower with 3 vestigial, apocarpous carpels, 9 stamens and 3 staminodes, hypogynous; carpellate flower with 6 syncarpous carpels and only 6 vestigial epigynous stamens.
4. *Vallisneria spiralis*—Carpellate flower solitary and large on a very long, spirally coiled peduncle by which the flower reaches the surface; staminate flowers minute, many on a very short peduncle, the individual flowers separated by an abscission layer and floating free on the surface.
5. *Phoenix dactylifera*—Decided dimorphism between the perianths of the staminate and carpellate flowers.

6. *Distichlis spicata*—Rachilla continuous in the staminate spikelet and the spikelets more numerous than in the carpellate inflorescence; rachilla of the carpellate spikelets articulated and the spikelets fewer in the inflorescence.
7. *Bulbilis dactyloides*—Decided dimorphism between the staminate and carpellate inflorescences and spikelets.
8. *Spinifex hirsuta*—With decided sexual dimorphism of the inflorescences.
9. *Similax herbacea*—Perianth segments of the staminate flowers larger than those of the carpellate flowers.
10. *Arisaema triphyllum*—Peduncle of the carpellate inflorescence much more persistent than that of the staminate inflorescence.
11. *Dioscorea villosa*—Carpellate inflorescence a simple catkin-like spike with few flowers; staminate inflorescence a branched panicle, the branches slender and spike-like with numerous flowers.
12. *Thalictrum dioicum*—Sepal of the carpellate flower about twice as long and wide as of the staminate flower, oval or obovate, while the sepal of the staminate flower is narrowly ovate and with a somewhat narrowed tip.
13. *Mercurialis annua*—Staminate flowers in elongated axillary spikes or racemes; carpellate flowers in the axils of the leaves.
14. *Carica papaya*—Inflorescence and flowers decidedly dimorphic; staminate flowers sympetalous in large, much branched inflorescences; carpellate flowers choripetalous in small slightly branched inflorescences or solitary.
15. *Papyrius papyrifera*—Staminate flowers in cylindric ament-like spikes; carpellate flowers capitate.
16. *Cannabis sativa*—Both the vegetative parts and the flowers with decided sexual dimorphism. In winter-grown hemp second internode of staminate plants about twice as long as that of carpellate plants.
17. *Humulus japonicus*—Both the inflorescence and the vegtative parts of the flowers show decided sexual dimorphism.
18. *Baccharis halimifolia*—Heads of the staminate and carpellate plants dimorphic.
19. *Anaphalis margaritacea*—Staminate and carpellate corollas dimorphic.
20. *Antennaria plantaginifolia*—Involucral bracts, pappus bristles, and corollas of the staminate and carpellate heads strongly dimorphic.

Vestigial Sporoplylls.

Below are given brief lists of some of the species studied by the writer to show the four possible types of distribution of vestiges of the opposite sporophylls in monosporangiate flowers. Cases in which vestiges are present in one flower and not in the other are to be regarded as sexual dimorphisms or sex-limited characters the same as dimorphisms in the vegetative parts; for the experiments on hemp and other plants show that the potentialities for both sporophylls are present

even when there is no vestige whatever expressed under normal conditions.

1. Monecious and diecious plants with sporohyll vestiges in both staminate and carpellate flowers—*Sagittaria latifolia*, monecious; *Phoenix dactylifera*, diecious, *Cocos nucifera*, monecious; *Zizania aquatica*, monecious; *Tripsacum dactyloides*, monecious; *Asparagus officinalis*, diecious; *Hydrocharis morsus-ranae*, diecious; *Chamaelirium luteum*, diecious; *Dioscorea villosa*, diecious; *Musa sapientum*, monecious; *Gymnocladus dioica*, diecious; *Lychnis alba*, diecious; *Acer platanoides*, diecious; *Rhus glabra*, diecious; *Acer saccharinum*, diecious; *Schmaltzia crenata*, diecious; *Coix lacryma*, monecious; *Sassafras sassafras*, diecious; *Ailanthus glandulosa*, diecious; *Ptelia trifoliata*, diecious; *Rumex altissimus*, monecious; *Aruncus aruncus*, diecious; *Platanus occidentalis*, monecious; *Aesculus glabra*, monecious; *Cucumis sativus*, monecious; *Diospyros virginiana*, diecious; *Silphium integrifolium*, monecious.

2. Monecious and diecious plants with stamen vestiges in the carpellate flowers but without a vestige of the gynecium in the staminate flowers—*Vallisneria spiralis*, diecious; *Smilax hispida*, diecious; *Peltandra virginica*, monecious; *Zantedeschia aethiopica*, monecious; *Menispermum canadense*, diecious; *Napea dioica*, diecious.

3. Monecious and diecious plants with carpel vestiges in the staminate flowers but without stamen vestiges in the carpellate flowers—*Tumboa bainesii*, diecious; *Carica papaya*, diecious; *Ambrosia trifida*, monecious; *Rumex acetocella*, diecious; *Amaranthus retroflexus*, monecious; *Morus alba*, diecious.

4. Monecious and diecious plants with no vestigial sporophylls normally either in the staminate or carpellate flowers. In general none of the primitive types of flowers like Pinus, Zamia, or Juniperus show any indication of the opposite type of sporophylls and frequently the extreme types of monocotyls and dicotyls also show no such vestiges. Occasionally low types of diecious angiosperms also show no vestiges like the diecious or partially diecious Thalictrums altho they have plainly been derived from bisporangiate ancestors like the Thalictrums with bisporangiate flowers—*Alocasia odorata*, monecious, *Arisaema triphyllum*, diecious; *Typha latifolia*, monecious; *Carex* sp., monecious and diecious; *Thalictrum dioicum*, diecious; *Cannabis sativa*, diecious; *Humulus japonicus*, diecious; *Acer negundo*, diecious; *Populus deltoides*, diecious; *Begonia* sp., monecious; *Sicyos angulatus*, monecious.

DEVELOPMENT OF THE MALE GONOPODS AND LIFE HISTORY STUDIES OF A POLYDESMID MILLIPEDE.*

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Introduction

The gonopod of the male millipede is at present the chief diagnostic character in identifying species. Therefore the development of these structures is interesting and important in the study of the millipede group.

For a study of this development *Euryurus erythropygus* (Brandt), a Polydesmid millipede, was chosen because they were found in abundance and thrived in the laboratory.

Since so little is known regarding the life-history and habits of the Polydesmidae or of the millipedes in general, opportunity was taken to study certain anatomical features; copulation; oviposition; characteristics of the eggs and the post-embryonic development. With regard to the latter the instars in the life-history were determined; studies made of ecdyses and of the cocoons. The cocoons are hollow, somewhat spherical chambers in which ecdyses of the instars occurs.

The research upon which this report is based was carried on chiefly at Miami University, Oxford, Ohio, during the school year 1924–1925. Observations were continued at The Lake Laboratory, Put-in-Bay, Ohio, and at The Ohio State University.

Grateful acknowledgment is made to Dr. Stephen R. Williams of Miami University, for direction of the work, and to Dr. Raymond C. Osburn, of The Ohio State University, for advice and criticism.

Materials and Methods

While collecting Myriapods in Ohio, near Oxford, during the latter part of September and in October, 1924, it was observed that specimens of *Euryurus* were abundant in the

* Portion of a thesis submitted in partial fulfillment of the requirements for the Degree of Master of Science (1925).

heartwood of much decayed logs, in moist and more decayed wood, usually sapwood, and under decaying wood if rather moist conditions prevailed. With a hope that they would breed and endure captivity in the laboratory, the specimens collected were placed in glass receptacles approximately five and one-half inches in diameter and three and one-eighth inches deep. These were half filled with small broken up pieces of moist and much decayed sapwood from an old rotten log and a little humus. A layer of vaseline was spread around the rims of the receptacles and glass covers placed over them,

TABLE I.

STAGES FOUND, MEAN MEASUREMENTS OF WIDTH AND LENGTH OF THREE INDIVIDUALS OF EACH STAGE, NUMBER OF SEGMENTS AND PAIRS OF LIMBS ON EACH SEGMENT.

Stages	Number of Segments	Number of Pairs of Legs		Length in Millimeters	Width in Millimeters
		Male	Female		
1st larval stage.....	7	3	.....	1.32	.345
2nd larval stage.....	9	6	.....	2.13	.556
3rd larval stage.....	12	11	.....	3.47	.916
4th larval stage.....	15	16	17	5.91	1.15
5th larval stage.....	17	22	23	8.46	1.72
6th larval stage.....	18	26	27	12.4	2.20
7th larval stage.....	19	28	29	19.3	3.30
8th stage (adult).....	20	30	31	29.1	4.13

Width—distance between the lateral edges of the tergites.
Length—distance from forehead to tip of anal segment.

All the animals measured were males except possibly some females among those individuals of the first three larval stages where it was impossible to distinguish sex.

thus insuring very little, if any, evaporation. However, a few drops of water were added occasionally and moisture and other conditions were kept as natural as possible. Some of the receptacles were opened every day, others nearly as often, for observations and fresh air entered at these times. Later observations indicate that this exchange is not frequently necessary because some receptacles were not opened often but the animals appeared to thrive as well as others. *Euryurus* is therefore easily kept in captivity and breeds and thrives in the artificial environment described. A number reared in the laboratory survived during the summer and during most of the fall of 1925, at The Ohio State University. The humus

and small pieces of decayed sapwood, placed in the receptacles, were examined carefully for contaminating forms, such as other Millipedes, centipedes, mites, earthworms, eggs, insect larvae, pupae, etc., and those found were removed. However, enchytraeid worms, some earthworms, craneflies, thysanura, mites, ticks and a few beetle larvae were later found in some of the receptacles so the elimination was not complete. Adult males and females observed copulating and, in some cases males and females not pairing, were isolated in separate receptacles. In most of the jars the females laid eggs and these were permitted to hatch in the same receptacle with the adults. As soon as the larvae started emerging from the eggs, a number of the small specimens were placed in Petri dishes in order to observe their habits more accurately. An abundance of material was available for study. Observations of the larvae were continued through their metamorphosis, thus the larval stages in the life history were determined and certain other observations recorded.

In studying the development of the gonopods at least three individuals of each stage were used,—in most cases more—and the gonopods of each stage when possible were examined in the following ways:—(1) Many dissections of each of the different stages in the development were made, dehydrated, cleared and mounted on slides. In the earlier stages, especially, it was not possible to study the gonopods carefully without doing this. (2) The gonopods were dissected from a number of freshly killed individuals in stages seven and eight and drawn without mounting. (3) All the steps in the developing gonopods were also studied in place on freshly killed individuals.

Camera lucida drawings, made at different levels by focusing, were put together to indicate the form of the structures studied. There were variations but, in general, the pattern was nearly uniform. When possible the mounted structures were studied under the high power objective.

Photographs were taken of larval stages and the adult; of some incomplete and completed cocoons, which are hollow, somewhat spherical chambers in which ecydses of the larval stages occurs; of the cast chitin of an animal which had completed ecdysis from the last larval stage to the adult.

Synonymy and Distribution

Polydesmus erythropygus. Nov.

1839. Brandt, J. F. Note Relative a la classification Des Especies Qui Composent Le Genre Polydesmus.

Polydesmus erythropygus.

1841. Brandt, J. F. Recueil, 134.

Euryurus maculatus.

1847. Koch, System d. Myriap., 138.

Polydesmus (*Paradesmus*) *carolinensis*.

1859. Saussure, Linnea Entomologica XIII, 325.

Euryurus maculatus.

1863. Koch, Die Myriapoden. Bd. 1, 7 to III, fig. 8.

Polydesmus Subgenus *Paradesmus erythropygus*.

1865. Wood, Trans. Am. Phil. Soc. XIII, 218.

Euryurus erythropygus.

1888. Bollman, Notes on a Coll. of Myriapoda from E. Tennessee, Ann. N. Y. Ac. Sci. X, pp. 106-112.

E. erythropygus—Common in E. Tennessee (Beaver Creek), Proc. U. S. Nat. Mus., XI, pp. 339-342. Notes on a Coll. of Myriapods from Mossy Creek, Tennessee.

E. erythropygus—Common. Cat. of Myriapods of Ind. Proc. U. S. Nat. Mus., XI, pp. 403-410.

E. erythropygus—Abundant. Notes on the N. Am. Myriapods described by C. L. Koch.

E. maculatus Koch. Syst. Myr., 138, 1847 (? habitat); Die Myr., 1, 7, pl. 3, fig. 8, 1863. According to Peters *maculatus* is the same as *E. erythropygus* (Brandt).

Distribution of *Euryurus*

From the literature that was accessible *Euryurus* is known only from Africa and the United States of America. A list of this literature is included in the Bibliography.

Dr. C. L. Koch, ('63), reports the country unknown.

H. C. Wood, ('65), *Euryurus erythopygus* is found in Western Pennsylvania and Illinois.

Dr. R. Latzel, ('84), reports it for Africa and America.

Bollman, ('93), gives the following data concerning the habitat of this species:— (a) Common in Tennessee at Beaver Creek, Jefferson Co., East Mossy Creek. (b) Abundant in Indiana at Bloomington, Boswell, La Fayette, Kokomo, Westfield, Terre Haute, Greencastle, Mitchell, Salem, New Providence, Brookville, Wyandotte.

In 1924–1925, the writer found the animals abundant in southwestern Ohio, near Oxford, in Butler County.

Description.

The body is convex on its dorsal and ventral surfaces and in the adult is made up of twenty body segments besides the head. They can roll up into a spiral but not into a ball. The tergites are elevated in the middle, more so in the female than the male. The body segments, with the exception of the first, are entirely fused into a ring, that is, the tergites are fused with their appropriate pleurites and these with the appropriate sternites. This is characteristic of the *Polydesmidae.* The first sternum alone is free. The body is hard, the dorsal side smooth, shining and naked, with brilliant orange spots. There is a rather large semicircular orange spot on the posterior edge of each of the tergites. The orange color varies in intensity, in some it is deep orange, in some light.

This color bleaches out almost or entirely in alcohol or if allowed to dry. On each tergite olive-chestnut colored areas are arranged around the orange spots. The color becomes darker toward the maculae. The keels or lateral edges of the tergites are colored orange. These keels or edges of the body segments are very prominent, wing-like and powerfully developed and the prominent longitudinal ridges found on them bear the repugnatorial pores. These pores are found on the keels of segments 5, 7, 9, 10, 12, 13, 15, 16, 17, 18, 19 and are surrounded by long oval swellings on the dorsal side of the keels. The keels of the four segments next to the last and the first five behind the head are crowded together so that they slightly overlap each other.

The mandibles present on the side of the head project like cheeks. One pair of maxillae is present. They have united to form a well developed lower lip, the gnathochilarium. No maxillipedes are present.

The head is smooth, hard and shining and a rather deep dorso-ventral cross furrow was observed on the olive-colored forehead in the middle above the level of the bases of the antennae. The animal is eyeless. The antennae are short and are composed of eight antennal joints in adults.

In most individuals there is a well marked black, median line along the dorsum. This is especially noticeable in the larval stages before the pigment develops and in individuals of a slate color. In larval stages the margins of the lateral carinae appear faintly orange in the third moult before the

adult in some specimens. Gradually the color increases and the chestnut and olive and slate colors appear in the stage preceding the adult. The ventral side and the legs are dull yellow in color. After drying for a while or if preserved in alcohol or glycerine or a mixture of both, they become a yellowish brown color.

The legs are somewhat hairy but without special characteristics. The eighth pair of legs specially modified as gonopods are present on the seventh sternite of the male of all except the first three larval stages, in which they have not yet appeared. The paired openings of the vasa deferentia are found on projections located on the coxal joints of the second pair of legs. Genital structures (vulvae) are found in a somewhat similar position attached near the base of the second pair of legs in the female.

The anal segment is quadrate, trapezoidal and broad. There is an anal plate on either side of the anal opening. The anal scale is broad and rounded posteriorly. It is rather large and tapers and a few hairs project from its ends and sides. There is an orange spot on its posterior margin.

Some conclusions regarding differences between adult males and females.

1. Females were more numerous than males.
2. The legs of males are slightly longer than those of the females.
3. Females thicker dorso-ventrally than males.
4. Females slightly longer than males.
5. Females slightly wider than males.
6. Chestnut color of females often darker than that of males.
7. The longitudinal ridges along the keels of the males appear to be more prominent than on the females.
8. Females have thirty-one pairs of legs, vulvae developed on the second pair.
9. Males have thirty pairs of walking legs with sex organs opening on the coxapods of the second pair and the eighth pair modified into gonopods or copulatory organs.

Life History

(*a*) Description of copulation.

In copulation the male is usually above the female and with dorsal surface up and head bent over the anterior part of the female which is usually below with ventral side up in contact with the ventral side of the male. The anterior legs of the male are used to clasp the female, hooking over the keels or edges of the tergites. The gonopods enter the vulvae of the female.

(*b*) Observations concerning the eggs:

(1) Oviposition.

In most cases the females laid their eggs in cavities made by themselves a short distance below the surface of the soil. Under natural conditions the eggs have been observed in small cavities in much decayed logs.

(2) Numbers laid.

Under artificial conditions in the laboratory, in one case 526 eggs were counted. On April 18, 1925, while collecting, a single nest of eggs was found in a small cavity. The nest was brought in with extreme care, and found to contain 586 eggs.

(3) Size, shape, color, coating.

The eggs are very small and coated with a glutinous fluid which causes them to adhere in clusters. They are usually spherical, and greenish yellow in color, but some oval, some opaque and some brown eggs were found. The usual diameter of oval eggs was from .44 to .45 mm., and the length .53 to .534 mm.; the dimensions of the spherical ones .516 to .518 mm. by .520 to .524 mm.

(4) Constitution:

Myriapod eggs, according to Korschelt and Heider ('99, vol. 3, p. 219) "are very rich in yolk and are surrounded by a vitelline membrane and another structureless but firmer envelop, the chorion, which is apparently secreted by the genital ducts." This description may be applied to the eggs of *Eury-urus*. The egg envelop was observed when split and the young forms were about to emerge.

(5) Time of hatching:

(a) Laid October 4, 1924; hatched Nov. 8 (36 days).

(b) Laid October 31, 1924; hatched Dec. 17. (48 days.)

(c) Laid December 19, 1924; hatched Jan, 28, 1925. (41 days.)

Eggs collected in their natural environment and brought to the laboratory April 18, 1925, were hatched by May 16. (29 days.) Time of laying not known.

In one case not observed as closely as the above, a male and female were observed copulating December 17, 1924, and were placed in a separate receptacle. The eggs were not observed but sixty-five days later on February 19, 1925, individuals of the first larval stage were found. In another similar case sixty-eight days elapsed. In the latter case the weather was colder.

(*c*) Post-embryonic development.

(1) The stages, ecdyses, intervals between them and cocoon building.

Stages

The larvae of *Euryurus* apart from the smaller number of segments and lack of pigment in the earlier stages, does not differ greatly in form from the adult. The first larval stage possesses three pairs of legs. According to Korschelt and Heider ('99, vol. 3, p. 236), "The possession of three pairs of legs by the first larval stage brings about a striking resemblance to an insect larva..... This is, of course, merely an external resemblance, for, in the first place, the homology of the cephalic regions of the insects and the Myriapods (in respect of the number of segments utilized in the formation of the head), is still very doubtful, and further in the latter, one of the anterior trunk segments, usually the second, is, as a rule, devoid of extremities, so that the first three pairs of legs are distributed on four segments, whereas the thorax of the Insects, as is well known, consists of three segments, each possessing a pair of limbs."

In the post-embryonic development of *Euryurus* the additions are in the form of the double segments characteristic of the Diplopoda.

(Korschelt-Heider '99, Vol. 3, pp. 237-238) "The formation of new somites always takes place between the anal segment and that last developed (Latzel), and the formation of double segments is now proved to be due to the fusion of two of the originally distinct primitive segments (Heathcote.) The six-

limbed larvae has several other pairs of legs as rudiments beneath the integument. The number of these varies in different forms. It is characteristic of the terminal segment in the Diplopoda that no fusion takes place in it, and this is also the case with the four anterior segments (known as the thorax), and, apparently, fusion is also absent in the genital segment."

The post-embryonic development of *Euryurus*, as shown in the table given on page 26, is characterized by seven moults. Fig. 6 is a picture of the larval stages and the adult stage. A single pair of legs is found on the first, third and fourth trunk segments of all the stages, the second trunk segment lacks limbs in every case in *Euryurus*. Sexual maturity is reached in the eighth stage. Adults have not been observed to moult. Besides the single pairs of legs on the first, third and fourth trunk segments of the first larval stage, two truncated pairs of legs are found lying below the integument, belonging to the fifth segment and a single pair of the same kind the sixth segment. These limbs project freely after ecdysis. No intermediate sizes between the stages were found.

The post-embryonic development of *Euryurus* as observed by the writer, is similar to that of the genus *Polydesmus*, given by Drs. R. Latzel and O. vom Rath, except that for the third stage they have recorded observing ten pairs of legs for males and eleven pairs for females. The writer examined carefully sixty-six individuals of the third larval stage of *Euryurus*, and found all of these to possess eleven pairs of legs.

Fifty-six of these individuals examined were reared in the laboratory. On April 20, 1925, ten forms collected April 18, 19 , from their natural environment, were inspected and all of these had eleven pairs of legs. As females are more numerous than males in this species, there was the possibility that all the animals examined having eleven pairs of legs were females. Eight specimens, each having eleven pairs of legs, were isolated in a Petri dish in which soil had been placed, which had been carefully examined to make sure that no other *Euryurus* larvae were present. After ecdysis had occurred, two were found which had sixteen pairs of legs, this distinguishing them definitely as males and six were found possessing seventeen pairs of legs distinguishing them as females. This is conclusive evidence that all of the sixty-six individuals previously examined, were probably not females. Ten individuals of the third larval stage of *Oxidus* (*Paradesmus*) *gracilis*, another Polydesmid,

were examined and no individuals with ten pairs of legs were found. None of this species were reared to the next stage.

Eggs of *Polydesmus serratus* were collected under natural conditions (April, 1925), and brought in and hatched in the laboratory. Eight individuals reaching the third larval stage were carefully examined by Dr. Williams and myself, and all eight were found to possess eleven pairs of legs. These were isolated in a glass container and brought to the Lake Laboratory and there reared to the next stage, in which the first individual examined had sixteen pairs of legs, thus distinguishing it as a male.

Ecdysis.

Euryurus attains its full sexual character after seven moults, in each of which the chitinous cuticle is entirely thrown off and replaced by a new one secreted by the epidermis or hypodermis just under it. The exoskeleton is shed after each larval stage, but has not been observed to be shed by adult animals. Ecdysis is performed at intervals in the larval stages.

Table Showing the Shortest and Longest Times Observed for the Instars or Stages Between Ecdyses.

1st Instar	5 to 14 days
2nd Instar	14 to 20 days
3rd Instar	22 to 24 days
4th Instar	26 to 30 days
5th Instar	31 to 34 days
6th Instar	41 to 41 days
7th Instar	44 to 47 days
Hatching of Eggs	29 to 48 days
Lengths of life history	212 to 258 days

The ecdyses of individuals in cocoons were followed to find out if possible how ecdysis occurs and to look for intermediate steps in the development of the gonopods between stages three and four and seven and eight.

To determine whether moisture is a factor in the length of time for ecdysis, an experiment was performed in which the temperature was fairly uniform but moisture was varied. (a) In one Petri dish individuals of the first larval stage were placed in a rather moist environment. (b) In another dish similar individuals were placed in a considerably drier environment. Animals in the conditions designated in (a) moulted in from 6–8 days. Animals in (b) moulted in from 13–14 days. These results indicate that it takes a longer time for ecdysis

under rather dry conditions. With these cases and others observed other conditions such as temperature and confinement may have also modified the intervals so that they may vary from those occurring under natural conditions.

Method of Ecdysis Derived From Studying Some Cast Skins of Larval Stages.

Fig. 7 is a picture of the cast skin of a female which had moulted from the last larval stage to the adult stage. The old chitin had split down the mid-ventral line and also somewhat laterally, just above the attachment of the legs on one or both sides. The dorsal surface seemed intact in this and in other casts observed. The cast was disarticulated at the junction of the head and first segment and the animal must have crept forward, causing the anterior end to crowd together somewhat. This was also noticed in other casts observed.

Cocoon Building.

The larvae of each stage build their cocoons as follows:— Small bits of much decayed wood, or earth are moistened with a sticky fluid, presumably secreted by the salivary glands.

The materials used are worked up with the jaws and front legs and when of a suitable size are placed together. The completed cocoons are shaped somewhat like a hollow sphere (Fig. 9.) The inside is rather smooth and even and the outside is rough. The shape and size of the materials of which it is composed can be readily discerned. A small stack or bluntly rounded chimney-like projection is made and closed up at the top. Indicated by the arrow in Fig. 9. Fig. 8 is a photograph of three cocoons in the process of construction by forms of the seventh larval stage. The one slightly to the left of the center is the result of the work of one individual for about one day and represents the base. The animal was continuing this construction just before this picture was taken. As soon as disturbed it disappeared. The small bits of materials are put into place from the inside and the individuals work around. The other two cocoons in the picture are much nearer completion than the one described and represented from two and one-half to three days work. The animal at the base of the upper one on the right was working inside and when interrupted to take the photograph it made a hasty retreat for a millipede, hence the somewhat blurred picture of it. The

cocoons in the photograph were constructed on the upper surface of pieces of rotten wood lying on top of the other material in the glass receptacles and were photographed in place. Some animals in the fifth, sixth and seventh larval stages built their cocoons on the side of the receptacles above the surface of the contents. Fig. 9 is a photograph of two completed cocoons and the animals are enclosed in them. These were built by individuals of the last larval stage. Three and one-half to four days were required for their construction. Dimensions of the upper cocoon:

Width at bottom where attached = 18mm.
Width of the chimney-like projection = 5 mm.
Height of the whole cocoon, including the chimney = 21 mm.

Notes on the time it takes to build the cocoons in which the last larval stages moult:

A. (1) A female started construction Jan. 12, 1925.
(2) Finished on Jan. 16.
(3) Emerged from the top March 3. (47 days.)
The chimney-like projection was broken off.
Measurements of the cocoon:—
Width at bottom = 17mm.
Height to the projection = 13.5 mm.
Height of the projection = 4.5 mm.
Width of the projection = 5.0 mm.

B. Cocoon started by a male on Jan. 28, 1925, was completed Jan. 31. This was built along the side of a glass receptacle a short distance above the level of the contents.

Most of the cocoons built by the other larval stages were built below the surface. The animals are very helpless a short time after they close up their cocoons. If a cocoon is opened and the animal disturbed when in the midst of ecdysis no motions can be perceived, indicating that they are absolutely helpless during this process. Near the completion of ecdysis motion is apparent. Presumably the cocoons are built for protection. Three individuals in the midst of ecdyses from stage three to four were observed to be eaten by a beetle larva.

On April 19, 1925, cocoons and larval stages of *Euryurus* were found in their natural environment.

The Development of the Gonopods.

The gonopods of the male are modified from the eighth pair of legs on the seventh body segment. With naked eye or with low magnification in all the individuals of the third larval stage examined, the eighth pair of legs appeared to be

most appreciably smaller or otherwise different from the walking appendages. With higher powers of the microscope a measureable difference was found in some individuals after dissecting and mounting the eighth and ninth pairs of legs. In one typical specimen the eighth pair of legs were found to be .559 mm. long and the ninth pair .576 mm. long. It is presumed that the individual from which these were dissected was a male.

In another specimen the eighth pair of legs were .568 mm. long and the ninth pair .571 mm. long. The individual from which these were dissected might possibly have been a female.

In *Euryurus*, according to observations, the modification of the male gonopods, which are found in the place of the eighth pair of legs, appears first in the fourth larval stage. Following are the steps found in the development of the gonopods, with description and measurements of each.

First Step.

On the fourth larval stage in place of each of the eighth pair of legs of the preceding stage, a single joint is found outlined by an oval bounding line. (Fig. 1.) Measurements of the joints = .077 mm.; heighth = .043 mm.

Second Step.

In the fifth larval stage two joints were found in place of the one found previously. This time the two pairs of these joints are placed symmetrically in a small oval disc. (Fig. 2.) The joints could not be dissected from the disc because of their delicacy so the whole sternite and the ninth pair of legs were mounted. Measurements: Length of oval disc = .292 mm.; width, .112 mm.; first joint, length = .103 mm.; width = .065 mm.; second joint, length = .073 mm.; width = .052 mm.

Third Step.

In the next larval stage, three joints representing each appendage were found in a larger oval disc. (Fig. 3.) Measurements:—length of oval disc = .361 mm.; width = .206 mm.

First joint	*Second joint*	*Third joint*
Length = .146 mm.	Length = .138 mm.	Length = .103 mm.
Width = .141 mm.	Width = .123 mm.	Width = .060 mm.

The line across the oval disc, projecting slightly on either side, probably represents a boundary line between sternites.

Fourth Step.

In the last larval stage, each appendage shows three joints as before, but considerably changed and enlarged and for the first time free from the sternite and lying in an oval opening in it. (Fig. 4.) The dotted lines outlining the first joints indicates that the greater part of these lies in a cavity under the sternite. Measurements: length of oval opening = .705 mm.; width of oval opening = .370 mm.

First joint	*Second joint*	*Third joint*
Length = .215 mm.	Length = .327 mm.	Length = .292 mm.
Width = .202 mm.	Width = .146 mm.	Width = .258 mm.

The gonopods shown in 4B were dissected from a freshly killed specimen and drawn without mounting. Divisions were observed on the basal joints and are indicated by lines. The shaded areas indicate depressions in the secondand third joints. There are cavities opening to the outside designated by a and e. There seemed to be a cavity or hollow space inside the proximal joint of each gonopod when examined from a dorsal view.

In the drawings of mounted gonopods studied under a higher magnification more details could be observed. (Fig. 4A.) The third or distal joint appears to be attached only at the outer edge. In one case examined, the terminal joint showed the structure as indicated by the distal joint (d. j.) on the left gonopod. (Fig. 4A.) A comparison with the adult gonopods, Fig. 5 shows a similarity. Other similar cases were observed. Thus the terminal section of the gonopod is differentiated from the third joint by the breaking away of the wall on the inner proximal corner and then, by straightening somewhat, produces the curved adult distal joint. The proximal joint is large and represents the coxal joint of the appendage enlarged and differentiated. Whether the other joints have been cut off distally from it and certain structures of the adult gonopods in turn developed from these, or the distal joint of the three represents the first step in the development of the gonopod and the other joints have appeared one after the other behind it, is not determined.

The breaks in the chitin shown in Figures 4A and 4B must be in some way connected with the forming of the distal joint which later, by straightening and going laterally, will produce the curved end of the male organ.

Fifth Step.

No intermediate conditions during ecdysis between stages seven and eight were found. Sexual maturity is reached in the eighth stage and is accompanied by the complete copulating appendages as shown in Figures 5, 5A, 5B. The adult gonopods are curiously modified. At the base of each gonopod a large joint is found, known as the coxa copulativa. Dimensions:— Length = .989 mm.; width, = .654 mm. A transverse hook is attached to the inside of each of these, the purpose of which is probably for holding. In some gonopods mounted on slides this appeared tubular. On the concave side of the distal joint of the much curved gonopod is found a hairy elevation, pulvillus piligerus, for the reception of sperm. Immediately distal to this is located a blunt spine. A structure which looks like a tube starts below its proximal end and passes to the end of the long needle-like projection on the terminal curved section of the gonopod. In an endeavor to learn whether this was a tube some dissected gonopods were placed in stain. The stain did not penetrate into this, possibly hindered by capillarity or perhaps there is no passage. In general, the middle joint is narrow as compared to the other two and in some cases is wedge-shaped so that sometimes the proximal and distal joints touch each other on the outer edge. There is a terminal section which curves inward like a swan's neck and is distally bifid. "The forked fingers of these gonopods are long and needle-like and somewhat twisted." (Koch)

Numerous hair-like projections are found on the gonopods as indicated in Fig. 5A.

From the top of the second joint to the tip of the terminal section = 1.46 mm.

The oval opening through which the gonopods project has a rather high sharp edge. Dimensions:— width = .903 mm.; length = 1.25 mm. Specimen 1.

Specimen 2:— width, = .928 mm.; length, 1.29 mm.

Summary of the steps in the development of the Gonopods.

(1) Individuals of the third larval stage and eleven pairs of legs, with a somewhat reduced eighth pair of legs were thought to be males, the others females.

(2) In the next moult the eighth pair of legs have disappeared and in their place two very small joints appear.

(3) The fifth larval stage shows a small oval disc with two joints of each of the gonopods outlined.

(4) The next moult shows three joints on each side in a somewhat larger oval disc.

(5) In the last larval stage these appendages are free from the sternite and lie in an oval opening in it.

The terminal sections of the gonopod differentiate from the third joint by the breaking away of the wall on the inner proximal corner and then by straightening somewhat to produce the adult distal joint.

Proofs that the gonopods are modified from the eighth pair of legs:

(a) Commencing in the fourth stage the males have one less pair of legs than the females. The eighth pair of walking legs is missing in males.

(b) The males in stage three possess eleven pairs of legs the same as the females. In the moult between stages three and four, the eighth pair is lost and the rudiments of the gonopods appear in the fourth larval stage.

Summary.

I. Differences between adult males and females.

1. Females were slightly longer, wide, thicker and more numerous than males.
2. The legs of the males are slightly longer than those of the females.
3. Females have thirty-one pairs of legs with vulvae attached to the second pair.
4. Males have thirty pairs of walking legs with sex organs opening on the coxopods of the second pair of legs and the eighth pair of legs modified into gonopods or copulatory organs.

II. Post embryonic development.

The post-embryonic development of *Euryurus* is characterized by seven moults, with the addition of segments and pairs of limbs as shown in the table on page

III. Ecdysis.

1. Euryurus attains its full sexual character after seven ecdyses which are performed at rather short intervals and in cocoons.
2. The time required for ecdysis increases with each later larval stage.

IV. Gonopods.

The gonopods undergo a gradual progression and development from the fourth larval stage on to the adult stage.

BIBLIOGRAPHY.

BRANDT, J. F.
1839. Note Relative a la Classification des Especes Qui Composent le Genere Polydesmus, et Suivie d'une Caracteristique de Dix Especies Nouvelles, Ainsi Que de Quelques Remarques sur la Distribution Geografique des Especes en General. Extrait du Bull. Scientif. d. l'Acad. Imper. d. Sci. de St. Petersb. T. V., No. 20.

BRANDT, J. F.
1841. Recueil de memoires relatifs a l'ordre des Insectes Myriapodes. Extrait du Bull. scientif d. l'Acad. Imper. d. Sci. de St. Petersb. T. V. VI, VII, VIII, et IX. St. Petersbourg et Leipsic.

KOCH, C. L.
1863. Die Myriapoden. Vol. 1, p. 7-8, tab. III, fig. 8.

WOOD, H. C.
1865. The Myriapods of North Amer.. Art 7, p. 218-219.

LATZEL, R.
1884. Die Myr. der Ost. Ung. Monarchie. Vol. 2, pp. 40-63.

MCNEILL, G.
1887. List of Myriapods found in Escambia Co., Fla., with description of twelve new species chiefly from Indiana. Proc. U. S. Nat. Mus., vol. 10, p. 329, pl. xii.

BOLLMAN, C. H.
1893. The Myr. of North America. pp. 83, 91, 108, 123, 151.

KORSCHELT, E., AND HEIDER, K.
1899. Textbook of embryology of invertebrates. Translated by M. Bernard, edited by M. F. Woodward. Vol. 3, Myriapods, Ch. 26, p. 218-259, fig. 106-128.

SINCLAIR, F. G.
1910. Myriapods in Cambr. Nat. Hist., Vol. 5.

FIG. 1

FIG. 2

FIG. 3

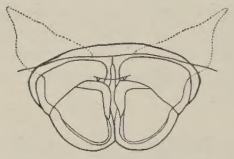
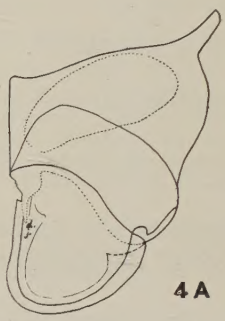
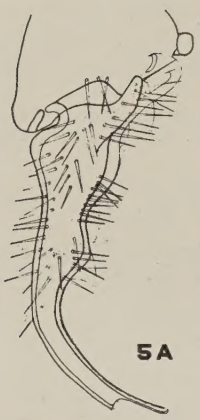


FIG. 4



4A

4B



5A

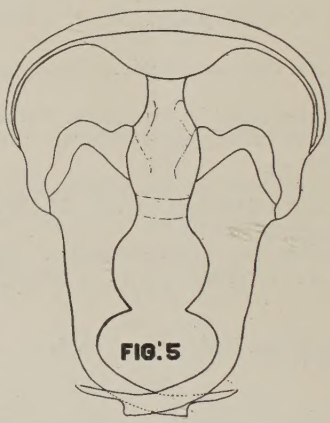


FIG. 5

5B

Each of the stages in the development of the gonopods was drawn to scale and shows the development as it progressed. The drawings, although necessarily slightly schematic, are in no sense mere diagrams, but are attempts to represent as closely as possible the actual appearance of the objects.

Unless otherwise specified, drawings from ventral side.

Fig. 1. The single joints or rudiments of the gonopods of a male of the fourth larval stage in place of the eighth pair of legs.

Fig. 2. Joints of the gonopods shown in the oval disc of an individual of the fifth larval stage.

Fig. 3. Joints of the gonopods of the sixth larval stage fastened to the oval disc.

Fig. 4. Joints of the gonopods in place, now free from the sternite, lying in an oval opening in it. Seventh larval stage.

Fig. 4A. Drawn from mounted gonopods, dissected from the last larval stage. Detailed drawing of left gonopod.

Fig. 4B. Gonopods dissected from a freshly killed individual of the last larval stage.

Fig. 5. Adult gonopods in place in a freshly killed specimen and the oval opening through which the gonopods project.

Fig. 5A. Right adult gonopod showing the numerous hair-like projections, and transverse hook attached to the coxa.

Fig. 5B. Dorsal view of right adult gonopod dissected and drawn from a freshly killed individual.

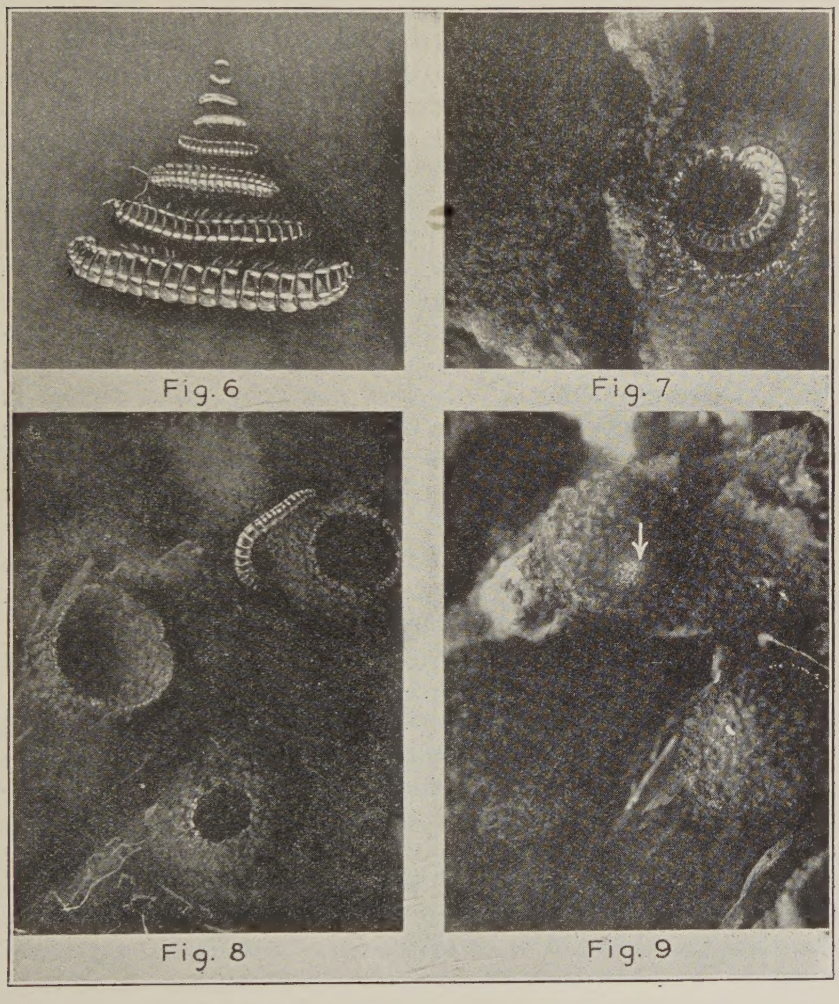


Fig. 6. Photograph of the larval stages and adult of Euryurus.

Fig. 7. Photograph of the cast "skin" of a female individual which has moulted from the last larval stage to the adult. The upper part of the cocoon was removed.

Fig. 8. Three cocoons in the process of construction. Two nearly completed and one recently started.

Fig. 9. Photograph of two completed cocoons. The arrow indicates the characteristic chimney-like projection built on top of these.

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